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J. C. Brammell

ABSTRACT

OF THE

PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

FOR THE FIRST TEN SESSIONS,

1859—69.

(The Authors having revised their own papers, are alone responsible for the facts and opinions expressed in them.)

LIVERPOOL:

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ABSTRACT OF THE PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

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ABSTRACT

OF THE PROCEEDINGS

OF

The Liverpool Geological Society,

SESSIONS THE FIRST AND SECOND,

1860–61.

LIVERPOOL:

C. TINLING, PRINTER, COURIER-OFFICE, CASTLE-STREET.

1861.

ABSTRACT OF THE PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

SESSION FIRST.

JANUARY 10TH, 1860.

The PRESIDENT, HENRY DUCKWORTH, F.G.S., F.R.G.S., in the Chair.

JOHN PHILLIPS, M.A., LL.D., F.R.S., F.G.S., Oxford; A. C. RAMSAY, F.R.S., London; J. B. JUKES, M.A., F.R.S., Dublin; J. MORRIS, F.G.S., London; S. J. MACKIE, F.G.S., F.S.A., London, were elected Honorary Members.

H. GRIFFITHS, Rev. Prof.; D. CAMERON, M.A,; CUTHBERT COLLINGWOOD, M.A., M.B., F.L.S.; OWEN LEWIS; WILLIAM G. HELSBY, were elected Ordinary Members.

The PRESIDENT then read his inauguration address.

After congratulating the Members on assembling together for the first time as a constituted body, he proceeded to point out the objects of the Society, and the benefit likely to arise to the community at large from the existence of such an association amongst them. The Geology of Liverpool and its immediate neighbourhood was next touched upon, and afterwards that of the surrounding country, especially of North Wales, the President calling particular attention to the comparative ease with which such deeply interesting localities as Church Stretton, Coalbrookdale, and Ludlow—the portals of the Silurian System—might be reached.

In a *resumé* of the progress of geological science during the past year, the President dwelt at considerable length on the important researches of Mr. Prestwick in the valley of the Somme, in France, and of Dr. Falconer in the Maccagnone caves, in Sicily, in connexion with that most interesting question of the day, "Man amongst the Mammoths." The meeting of the British Association at Aberdeen next came under consideration; the most important points in Sir Charles Lyell's able address being dilated upon. In conclusion, the President called attention to the principal geological books, and new editions of old works that had appeared during the preceding year.

The following communication was then read—

ON THE BASEMENT BED OF THE KEUPER FORMATION IN WIRRAL AND THE SOUTHWEST OF LANCASHIRE.

By GEORGE H. MORTON, F.G.S.

After referring to the subdivisons of the Trias, he described the characters of the "Upper Red and Variegated Sandstone" of the Bunter formation, showing that it had suffered a considerable amount of denudation previous to the deposition of the Keuper. A bed of the Upper Bunter Sandstone, in Wirral, is found to be almost entirely denuded on the northern side of the Mersey, only the faintest traces of it being visible. A slight unconformity seems very possible, but the surface of the Bunter is so eroded and uneven, that it is very difficult to arrive at an exact or a satisfactory conclusion upon that important point.

The base of the Keuper is very uniform in its lithological aspect throughout the district, being a conglomerate, or coarse sandstone, containing quartz, pebbles, and nodules of clay. In colour the bed varies, but it can always be distinguished by its hardness from the Bunter sandstone beneath.

For these and other minor reasons, the author stated, that the Bunter formation had been exposed to denudation for a long period prior to the deposition of the Keuper, and that the former was dry land during the time that the Muschelkalk was being formed in more southern and easterly regions. With the exception of the well known footprints of Emydians and Batrachians, not a trace of any animal had been found in either the Bunter or Keuper formations of the neighbourhood.

The examination of the three railway tunnels under the town of Liverpool, and of other artificial openings, satisfactorily proves that the basement bed of the Keuper, on the map of the Geological Survey, is altogether misplaced, and that the map requires correction, in order to render it an accurate guide to the local Geology.

MARCH 13TH, 1860.

THOMAS URQUHART, Esq., in the Chair.

The Honorary Secretary, GEORGE H. MORTON, F.G.S., exhibited a number of scratched boulders and shells, collected by him from the Boulder clay at Kirkdale. The stones were intimately connected with the grooved and striated surfaces of the sandstone in the neighbourhood of Liverpool.*

The Rev. HENRY H. HIGGINS brought forward his proposed arrangement of the recent and fossil species in the new Liverpool Museum. He proposes to arrange the fossils, without regard to the formations or systems of rocks in which they occur, with the recent species in the zoological collection. The Hon. Secretary, Dr. Collingwood, and most of the Members of the Society, advised a geological arrangement of the fossils by themselves, so that they would illustrate the general character of past and successive creations. The principal objections advanced against a formational arrangement were—the very

* Proceedings of the Literary and Philosophical Society, pages 35 and 62.

limited number of geological specimens—the difficulty of finding space for them!—and the desire of Naturalists to include the fossil species within one zoological series.

SESSION THE SECOND.

OCTOBER 9th, 1860.

The President, HENRY DUCKWORTH, F.G.S., F.R.G.S., in the Chair.

William S. Horton; George Turner; Geo. S. Worthy; James A. Picton, F.S.A.; John Abraham; and Rev. Henry H. Higgins, M.A., were elected Ordinary Members.

The election of Officers and the passing of new Laws occupied the evening.

OCTOBER 23rd, 1860.

The President, HENRY DUCKWORTH, F.G.S., F.R.G.S., in the Chair.

Rev. S. H. Cooke, M.A., was elected an Ordinary Member.

The following resolution, proposed by Professor Griffith and seconded by Mr. Marrat, was carried unanimously:

> "That the Geological Society would view with regret "any arrangement of the organic remains, in the new "Free Public Museum, which would not afford the "student of Geology the means of prosecuting his "researches. The Society, then, advocates a geological "arrangement of the fossils in groups, according to their "relative age and position in stratified series of rock "formations."

The following communications were then read—

"On Fulgurites from the Red Crag of Orford, Suffolk," by Henry Duckworth, F.G.S., F.R.G.S.

ON THE GEOLOGY OF THE NEIGHBOURHOOD OF SHELVE, IN SHROPSHIRE.

By G. H. MORTON, F.G.S.

This paper was illustrated by sections, also by a large and interesting collection of both upper and lower Silurian fossils, collected in the district by the author of the paper, and several other Members of the Society. A longitudinal range of hills presents very high land to the east of Shelve. Reposing thereon are the Stiper stones, rugged hills of siliceous sandstone, dipping west-northwest, the summits being about one thousand six hundred feet above the level of the sea. These are considered to represent the Lingula flags of North Wales. Small cavities are common in the hard sandstone, some of which Mr. Salter considers to show traces of Lingulæ. Annelide burrows have also been observed. Above the rocks, which are some three thousand feet thick, is a series of dark slaty strata, containing the following fossils:—*Didymograpsus geminus*, *Ogygia Portlockii*, *Æglina binodosa*, *Theca simplex*, *Cucullela anglica*, *Redonia complanata*, *Lingula plumbea*; also one or two species of Orthoceras and several indistinct forms. These have been found in the lowest accessible strata, and may be considered the earliest fossils in the district. The Llandeilo rocks above the Stiper stones are about fourteen thousand feet thick. The strata dip sixty and seventy degrees, and at smaller angles. Excepting in particular beds, fossils are rarely to be found, but in several places they occur in profusion, such as *Dictyonema sociale*, *Ogygia Buchii*, *Bellerophon perturbatus*, all of common occurrence in the upper Llandeilo. *Glyptocrinus basalis* (M'Coy) has also been found associated with *Trinucleus Lloydii*, and *Orthis striatula*, &c., high in series at Meadow Town. Many of the Shelve fossils are figured in the second edition of Siluria.

The "Corndon," the highest isolated hill in the locality, is a great outburst of trap rock. Beds of volcanic ashes, several feet thick, are interstratified with strata, containing organic remains at Marrington Dingle. At Hope quarry, two miles from Shelve church, the upper (Silurian) Llandovery rock is seen, reposing uncomformable upon rounded bosses of trap and Llandeilo rock. Near that place are high cliffs of contorted strata. The district is of extreme interest to geologists, for within a circular space of country some seven miles across, so many geological phenomena are to be studied under great advantages.

DECEMBER 11TH, 1860.

CUTHBERT COLLINGWOOD, M.A., M.B., F.L.S,

IN THE CHAIR.

William Brown, Esq., Richmond-hill, Liverpool, was elected an Honorary Member.

George Yates; Rev. William Banister, B.A.; William R. Brown; and William Dobson were elected Ordinary Members.

The Secretary read a letter from the Curator of the Royal Institution, giving the Members of the Liverpool Geological Society free access to the Museum of that Institution, which duly received a vote of thanks.

The following communication was then read—

ON THE CO-ORDINATION OF THE OOLITIC STRATA OF WILTSHIRE AND GLOUCESTERSHIRE WITH THAT OF YORKSHIRE.

By WILLIAM S. HORTON.

This paper was illustrated by a vertical section taken from Swindon to Birdlip, and compared with one of the Yorkshire coast from Filey to Whitby, also a horizontal one from Oxford

to Shotover Hill. After a short description of each bed, down to the Cornbrash, reference was made to the extreme variation exhibited by the succeeding strata, which were co-ordinated as follows:

Yorkshire.	Wilts and Gloucestershire.
Cornbrash.	Cornbrash.
Upper Shale and Sandstone.	Forest Marble, Bradford Clay.
Bath Oolite.	Bath Oolite.
Lower Shale and Sandstone.	Fuller's Earth.
Inferior Oolite.	Inferior Oolite.

Both the upper and lower shales and sandstones are of fresh water or estuary origin, and contain numerous plants, with Equisetum Columnare, sometimes retaining its erect position, and occasional thin seams of imperfect coal. The upper series may be observed to the south of Scarborough, in Gristhorpe Bay. At Stainton Dale and Peak Hill, which forms the south of Robin Hood's Bay, the lower series attain their greatest development, and are upwards of four hundred feet in thickness. At this spot the whole of the strata, from the Bath Oolite to the Upper Lias inclusive, may be observed in one grand section, which attains an elevation of nearly six hundred feet above the beach. The upper Lias forms an undercliff, from which the superincumbent lower Oolite strata rise almost perpendicularly, and are all but inaccessible.

JANUARY 15th, 1861.

The President, HENRY DUCKWORTH, F.G.S., F.R.G.S., in the Chair.

The following communications were then read—

ON THE FOSSILS OF PERIM ISLAND, IN THE GULF OF CAMBAY.

By HENRY DUCKWORTH, F.G.S., F.R.G.S.

The author stated that the strata of Perim consisted of conglomerates, sandstones, and clays, which were referred to

the Miocene age of the Tertiary. Teeth and bones of many large mammals have been discovered, remains of the Deinotherium, Mastodon, Sus, Rhinoceros, Hippotherium, Bramatherium, and Camelopardalis having been obtained. It appears that the Bramatherium is a genus peculiar to Perim. Several species of other genera have been found in that island only.

ON THE GEOLOGY OF AUST CLIFF, GLOUCESTERSHIRE.

By GEORGE S. WORTHY.

A description of the strata of this most interesting section, which consists of a base of carboniferous limestone, succeeded unconformable by new red marls, in which a considerable quantity of gypsum is found, and also strontian. The marls are succeeded by a portion of the lower Lias formation. This latter is of great interest, on account of the numerous fossils contained in some of the thin beds of limestone, etc., found there, one of the lowest beds of the Lias in this section being a thin stratum of calcareous conglomerate, containing a very great abundance of reptilian bones, coprolites, and fish remains, known as the bone bed.

FEBRUARY 12TH, 1861.

The PRESIDENT, HENRY DUCKWORTH, F.G.S., F.R.G.S.
In the Chair.

WILLIAM PENGELLY, F.G.S., Torquay, was elected an Honorary Member.

EDWARD B. FRANCEYS; DAVID WALKER, M.D., F.R.G.S.; WILLIAM H. WEIGHTMAN; ROBERT GEE, M.D.; and EDWARD STIRLING were elected Ordinary Members.

The PRESIDENT then read his annual address.

After reviewing the progress of the Society, and giving a sketch of the geology of Liverpool and the surrounding district, he proceeded to describe the leading geological and palæonto-

logical discoveries of the past year, dwelling more particularly on the very interesting facts elucidated in France by Messrs. Lartel, Gosse, de Vibraye, and de Verneuil, in connexion with that scientific question of the day, "the Geological Age of Man."

The discoveries of two new ossiferous caves in Sicily by Baron Anca, and the extensive explorations in the Gower Caverns, South Wales, by Dr. Falconer and Colonel Wood, were also described. In conclusion, the President reviewed the geological arguments in Mr. Darwin's work on the "Origin of Species," and Professor Phillip's "Origin and Succession of Life upon the Earth," and earnestly recommended the Members of the Society to study both sides of the question fully before forming any decided opinions on the subject.

ON THE GEOLOGY OF THE ARCTIC REGIONS,

VISITED DURING THE VOYAGE OF THE "FOX," IN THE YEARS 1857-8.

BY DAVID WALKER, M.D., F.R.G.S.

This paper was the result of the author's observations during the voyage of the "Fox" in search of Sir John Franklin. He stated that on approaching the coast of South Greenland, the appearance of the mountains at once shows their igneous origin, being composed of granite, gneiss, and mica-schist, with occasional intervals of quartzose rock. After proceeding along a coast line of five hundred miles, the volcanic rocks appear. These are first seen at Disco Island, and continue, with a few interruptions, as far north as the expedition reached. The precise formation of the land between Jones' Sound and Lancaster Sound is not known, but, from its tabular appearance, it is most likely Upper Silurian Limestone, as occurs further westward, in Barrow Strait.

To the southward of Lancaster Sound Silurian Limestone appears, as far as Possession Bay, when the primary and metamorphic rocks make their appearance.

Beyond Croker's Bay, as far westward as visited, the formation is Upper Silurian Limestone, the hills presenting tabulated fronts to the sea, with deep ravines intervening, rendering the hills cone-shaped. The shore of Barrow Strait is also made up of similar cone-shaped hills of Silurian Limestone. The west coast of Regent Inlet is of the same formation, but the fronts to seaward are much more elevated than on the north side of Barrow Strait. From Fury Point south to Bellot Strait the elevation of the land fronting the sea gradually decreases, until it is seen lying against the granite, which forms the backbone of the country.

The author exhibited many specimens of the fossils he had collected from the Upper Silurian Limestone described: Arctic species of the genera Loxonema, Encrinurus, Spirifer, Atrypa, Rhynchonella, &c. The resemblance of the specimens to those of Dudley and Coalbrookdale is very remarkable. The presence of raised beaches and of tertiary coal was also dilated upon.

MARCH 12TH, 1861.

The PRESIDENT, HENRY DUCKWORTH, F.G.S., F.R.G.S.

IN THE CHAIR.

GEORGE WALSH was elected an Ordinary Member.

The following communication was then read:

ON THE PLEISTOCENE DEPOSITS OF THE DISTRICT AROUND LIVERPOOL.

BY GEORGE H. MORTON, F.G.S.

The author divided all the superficial accumulations of the district into the following subdivisions:

Pleistocene Deposits.	Post-glacial. Average thickness 10 feet	Drift Sand. Bluish Silt. Submarine Forests.
	Glacial Average thickness 100 feet	Upper Drift Sand. Boulder Clay. Lower Drift Sand.

The lower drift sand, it was remarked, is generally beneath the boulder clay, where the latter is of any considerable thickness. It is seen to advantage in the cliffs on the shores of the Mersey, exhibiting nests or patches of gravel. There are shells; *Turritella communis* is common; *Nassa reticulata, Nucula oblonga*, fragments of *Natica, Patella*, and *Tellina* also occur.

The boulder clay is the dark red clay extensively used for brickmaking. It contains numerous pebbles and boulders, which in size vary from that of a pea to immense blocks 6 feet in diameter, many of them being striated and grooved by ice action. They consist of quartz, granite, sienite, porphyry, greenstone, basalt, slate, limestone, and rarely of new red sandstone. The shell *Turritella communis* is common, as in the underlying sands. *Mactra truncata* also occurs, with fragments of undetermined species.

The upper drift sand is of limited extent, but is well developed at the southeast of the town. No trace of shells nor any pebbles have been found.

The post-glacial deposits are evidently of later age than such inland formations as at Leeds and Oxford, for no trace of the elephant has been found. The only mammalian remains discovered in addition to those now living in the neighbourhood belong to *Bos primigenius, Bos longifrons*, and *Cervus elephas*. Skulls, horns, and bones of these animals have been found in silt, associated with several submarine forest beds, which occur at various depths in different places in the neighbourhood. A section at the north docks shows a submarine forest bed resting on the rock at the depth of 35 feet below the high water level of a 20 feet spring tide. A section beneath the Custom-house shows a similar bed with the trunks of trees 29 feet and

another 40 feet below a tide of the same height. A section across Wallasey Pool exhibits an old forest bed with remains of trees 39 feet below a similar tide. The sections were all taken during the construction of the docks. The Cheshire coast at Leasowe presents phenomena of the same kind, but with less apparent subsidence, being 3 feet at Leasowe Castle and 8 feet at Dove Point. At the latter place there are two higher land surfaces divided by beds of silt.

From these sections, the author concluded that a subsidence of the land of near 50 feet was indicated, and that it was uniform over its whole extent, a conclusion confirmed by observations in other places on the same coast. The difference in the amount of the depression shown by the several sections merely indicates the varying elevation of the original surface. The subsidence of the lowest submarine forests probably caused a considerable extension of the river Mersey about the time of the occupation of Great Britain by the Romans. The sinking of the old forest beds of Leasowe, Dove Point, and Formby, is known to be within the historical period.

FINIS.

ABSTRACT

OF THE

PROCEEDINGS

OF

The Liverpool Geological Society,

SESSION THE THIRD,

1861–62.

LIVERPOOL:

C. TINLING, PRINTER, COURIER-OFFICE, CASTLE-STREET.

1863.

ABSTRACT OF THE PROCEEDINGS

OF THE

Liverpool Geological Society.

SESSION THIRD.

OCTOBER 8TH, 1861.

THE REV. PROFESSOR HENRY GRIFFITHS, VICE-PRESIDENT, in the Chair.

H. DOBELL was elected an Ordinary Member.

The following communications were then read:

REPORT OF THE EXCURSION MADE BY THE SOCIETY TO HOLYWELL, JULY 11TH, 1861.

BY HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S.

THE Mountain Limestone of that neighbourhood contains many species of the ordinary fossils in profusion; *Productus giganteus*, *P. semireticulatus*, *Lithostrotion basaltiforme*, and *Syringopora geniculata* being the most common. The formation is there divided into the following sub-divisions:

1. Numerous beds of Chert.
2. Shale and Limestone, with concretions of Chert.
3. Black Limestone.
4. White Limestone.

The position of the Chert nodules in No. 2 is similar to that of the Flints in the Chalk, but their form is different, being round flat concretions, thick in the centre, and gradually thinning towards the circumference.

REPORT OF THE EXCURSION MADE BY THE SOCIETY TO COALBROOKDALE, JULY 31st, 1861.

By GEORGE H. MORTON, F.G.S.

The excursion occupied two days, which were devoted to examining the Silurian strata. The low land to the west of Coalbrookdale, towards Buildwas, is Wenlock Shale; the lofty ridge, including Benthall Edge and Lincoln Hill, is Wenlock Limestone, with the Millstone-grit and Coal-measures reposing thereon. The following fossils were collected upon the occasion:

WENLOCK LIMESTONE.

1. *Heliolites Murchisonii.*
2. „ *magastoma.*
3. *Propora tubulata.*
4. *Favosites Forbesii.*
5. „ *cristata.*
6. „ *fibrosa.*
7. *Lebecheia conferta.*
8. *Halysites catenularia.*
9. *Syringopora bifurcata.*
10. „ *facicularis.*
11. *Thecia Swindernana.*
12. *Cyathophyllum articulatum.*
13. *Omphyma Murchisonii.*
14. *Aveolites Grayii.*
15. *Cystiphyllum sp.*
16. *Calymena Blumenbachii.*
17. *Athyris tumida.*
18. *Rhynchonella spherica.*
19. „ *nucula.*

WENLOCK LIMESTONE.

20. *Rhynchonella borealis.*
21. *Atrypa marginalis.*
22. „ *reticularis.*
23. *Strophomena depressa.*
24. *Euomphalus rugosus.*
25. „ *discors.*
26. „ *sculptus.*
27. „ *funatus.*
28. „ *carinatus.*

WENLOCK SHALE.

29. *Encrinital Stems.*
30. *Calymena tuberculosa.*
31. *Lingula sp.*
32. *Orthis hybrida.*
33. „ *biloba.*
34. „ *elegantula.*
35. *Rhynchonella sp.*
36. *Leptena transversalis.*
37. *Acroculia?*

Crustacea are rare at Coalbrookdale, when compared with the same formation at Dudley.

ON THE INFERIOR OOLITE.

BY THE REV. S. H. COOKE, M.A.

The inferior Oolite, as developed among the Cotteswolds, especially near Cheltenham, consists of four chief divisions:

1. Ammonite Sands, about forty feet thick, by some considered to belong to the Upper Lias, but probably a transition bed between that and the Inferior Oolite. *Rhynchonella cynocephala,* and many of its ammonites are peculiar to it. The best sections are to be seen at Frocester and the Haresfield Hills.

2. Pea-grit or Pisolite, about forty feet in thickness, confined to the immediate neighbourhood of Cheltenham, pisolitic in structure, with many fossils, some being peculiar to it.

3. Freestone and Oolitic Marl series, about one hundred and ninety feet thick in Leckhampton Hill; the freestone is much quarried for building, but generally unfossiliferous. The Oolite-marl-bed, about seven feet thick, contains many fossils, which are very constant throughout. Near Stroud it contains a thin coral reef, with nerinæa.

4. Ragstone, about thirty-eight feet in thickness; a hard gritty rock, with many fossils. It is subdivided into Gryphite Grit, Trigonia Grit, and Pholadomya Grit. The first of these exclusively affords Gryphæa Buckmannii, which is also found in the Swiss Jura and Swabia; Chemnitzia, Pholadomya, and Gresslya abound in this division. It keeps a nearly constant thickness over the whole district, while all the inferior divisons, including the Upper Lias, thin out and gradually disappear towards the east and southeast. Thus, at Stonesfield the Ragstone is thirty feet thick, while all between it and the Upper Lias are omitted; the latter is six feet, resting on the Marlstone twenty-five feet.

Inferior Oolite is also developed near Dundry, where the chief fossiliferous bed probably corresponds in place with the Cheltenham Pisolite; also in Dorsetshire, near Bridport, where it forms the coast section, but is much disturbed by faults. Its fauna in these more southern localities differs much from the Cotteswoldian, the Bristol Coal-field having formed a complete barrier between them. It is also developed on the Yorkshire coast, near Scarborough.

NOVEMBER 12TH, 1861.

FREDERICK P. MARRAT, Esq., in the Chair.

Thomas Dobson, B.A.; James Hickie; James Anderson; Edgar E. Jarrold; R. J. Keen; T. R. Arnott; C. Davies; and Walter Weld were elected Ordinary Members.

The following communication was then read:

ON THE STONESFIELD SLATE, AND ITS ASSOCIATED STRATA.

By WILLIAM S. HORTON.

The term Stonesfield Slate is applied to a bed which forms the base of the Bath Oolite in certain localities of the counties of Oxford, Gloucester, and Northampton. It is typically developed at Stonesfield, near Woodstock. It consists of a finely laminated calcareous sandstone, and although of very inconsiderable thickness, rarely exceeding one foot, was formerly of considerable local value for roofing purposes. It is not exposed in

open quarries, but worked by means of shafts and galleries, the latter extending to a considerable distance from the mouths of the pits. The blocks of slate when first raised are very compact, but after being exposed to the action of frost split readily along the plains of bedding. The organic remains of this formation are numerous and varied, including several orders of plants, besides representatives of all the four great divisions of the animal kingdom. The plants are for the most part terrestrial, and include such forms as Pterophyllum, Zamia, and Sphenopteris. The small extreme branches of coniferous shrubs allied to the cypress and yew, which have received the namè of Thuytes, occur also. Several genera of insects are among the rarer fossils of the slate. The Mollusca are but limited in species. The fishes of Stonesfield form a large and beautiful group, belonging entirely to the Placoid and Ganoid orders. The most common remains of this kind are patatal teeth of the genera Strophodus and Peynodus. Teeth of the families Hybodontidoe and Sauroidei are also far from being uncommon. The most famous of the Stonesfield reptiles is the Megalosaurus Bucklandi. There is also one species of Teleosaurus, and one of Pterodactyle, and one small species of Chelonia. The remarkable catalogue of associated life exhibited by this formation is rendered still more complete by three genera of small mammalia. The Northamptonshire equivalent of this bed is a deposit of feruginous sand and ironstone, termed Northampton sand. It is worked as an iron ore near Blisworth. Its fossils are very scarce, and for the most part fragmentary, the Duston pits being the only ones where they are sufficiently well preserved to be capable of identification. From the fact of this Northampton sand resting on the Upper Lias without any intervening beds, some geologists have been disposed to regard it as the equivalent of the Upper Lias sand of Gloucestershire, but the fossil evidence is not in favour of this opinion, as all the species hitherto collected are identical with those of the Stonesfield Slate.

DECEMBER, 10TH, 1861.

WILLIAM S. HORTON, ESQ., in the Chair.

FREDERICK ELLIOTT; S. LEIGH GREGSON; and GEORGE HAWKINS were elected Ordinary members of the Society.

The following communications were read:

ON A FOSSIL ELYTRA FROM THE STONESFIELD SLATE.

BY C. S. GREGSON,

PRESIDENT NORTHERN ENTOMOLOGICAL SOCIETY.

The author stated that this wing-cover could not be referred to Buprestidæ, but is undoubtedly a Longicorne, and nearly allied to, though not identical with, Prionus Coriarius of the present day, which has the Elytra roughly punctured and three obscure raised lines, whilst the specimen under consideration has the whole surface divided equidistantly with these more deeply sunk lines on the disc of the elytra, and one well-defined mark on the side, carried down to the end of the wing-case. Specimens from South America so nearly approach the fossil in form that the author thought it advisable to refer it to the immediate locality of this genus, under the provisional name of Prionaroides Hortoni.

That the specimen should have been thought a Buprestidæ by persons unacquainted with the Longicornidæ may be well understood. It will, however, be found that its only character in common with the Buprestidæ is in its acutely pointed tip, and this may partly be accounted for by supposing the lower portion of the edge of the Elytra covered by the stone in which it occurs. But the great character by which it may be separated from any species in this extensive family is in the form of the shoulder of the Elytra. In Buprestidæ the shoulder is carried upwards and outwards, while in Prionadæ the Elytra are rounded, and slightly hollowed in the centre.

The markings on the wing-case go for little. Some Buprestidæ are quite smooth, others are magnificently sculptured;

and the same remarks apply to other families among the Celeopteras, and may be well seen in the genus Carabus.

"On the Geology of the Country Around Malvern."
By G. H. MORTON, F.G.S.

JANUARY 14th, 1862.
HENRY DUCKWORTH, Esq., F.G.S., F.L.S., F.R.G.S., in the Chair.

Joseph Mayer, John H. Macalister, and the Rev. C. Jones were elected Ordinary Members.

The following communications were then read:

"On the Connection Between Physical Geography and Geology."
By FREDERICK P. MARRAT.

"On the Geology of the Southern Portion of the Isle of Man."
By EDWARD B. FRANCEYS.

FEBRUARY 11th, 1862.
S. B. JACKSON, Esq., in the Chair.

Richard D. Manson was elected an Ordinary Member.

The following communication was then read:

ON THE SURFACE MARKINGS NEAR LIVERPOOL, SUPPOSED TO HAVE BEEN CAUSED BY ICE.

By GEORGE H. MORTON, F.G.S.

Towards the end of 1859 I gave an account, to the Literary and Philosophical Society of Liverpool, of certain indications of ice passing over and grooving the rocks in Toxteth Park. Since that time I have found the same appearances in two other places, and that a far greater interest is attached to the discovery than was at first anticipated. The following are the three localities:

Toxteth Park.—In a field between Park Hill Road and the Dingle. It is near a quarry in the "Pebble-beds" of the "Bunter" formation, where the strata dip 10° E. The surface of the rock inclines 5° N.E. The direction of the striations is N.W. by N., or more correctly N. 42° W., allowing for variation. After the discovery I employed a labourer to clear away some more of the "Boulder-clay," which originally covered the surface of the rock to the depth of about 9 feet, until at least 20 square yards were visible; and no doubt the appearances extend over a considerable extent. The elevation is about 120 feet above the level of the sea.

Boundary Lane, Kirkdale.—In the brickfields about 50 yards north of Boundary Street and 150 yards west of Gore Street, where about 10 yards of striated surface have been exposed for some years. The Sandstone belongs to the base of the "Keuper" formation. The surface inclines about 5° in the same direction as the grooves and furrows, N. 15° W. The elevation above the sea is about 80 feet.

New Road, Kirkdale.—The other locality is also in the brickfields, about 600 yards S.W. of Kirkdale Gaol, and about the same distance from that last referred to, with which it may possibly communicate. The Sandstone belongs to the base of the "Keuper," and the striated surface exposed is fully 500 square yards, inclining throughout at an angle of 7½° in the direction of the striæ, which is the same as in the contiguous example, N. 15° W. The elevation above the sea is 80 feet, or perhaps a little less.

At each of these places the Sandstone is smooth, but with numerous longitudinal grooves and furrows of varying distinctness. The most prominent are about an inch wide, and extend several yards in a perfectly straight line. In appearance they seem to have been caused by the passage of some heavy body across the rock; and as ice seems the only agent possible to produce the result, the grounding of icebergs in the Glacial Sea is probably the cause.

Polished striated boulders and small stones are common in the overlying "Boulder-clay," and shells also occur, but are rare.

NOTE.—Since this communication was read, I have found very distinct ice-grooves at Oxton, Cheshire, half a mile S.E. from the telegraph on Bidston Hill. The direction of the striations is N. 30° W., and the elevation *about* 120 feet above high water level.—October 8th, 1862. G. H. M.

"A BRIEF OUTLINE OF THE GEOLOGY OF THE COUNTRY ABOUT CLITHEROE, PENDLE HILL, AND BURNLEY."

BY G. H. MORTON, F.G.S.

MARCH 24TH, 1862.

THE PRESIDENT, HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S., in the Chair.

The following communications were read:

ON FLINT IMPLEMENTS FROM THE DRIFT,

BEING AN ACCOUNT OF A VISIT TO AMIENS AND ABBEVILLE DURING THE SUMMER OF 1861.

BY HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S.

Not very long ago I communicated to the Literary and Philosophical Society of Liverpool a memoir on the recent discoveries of flint implements in various caverns in the southwest of England, in Sicily, and in the Valley of the Somme, in France. Since then I have had the satisfaction of investigating some of the most interesting localities in the latter district, and I purpose to lay before you a brief account of my visit.

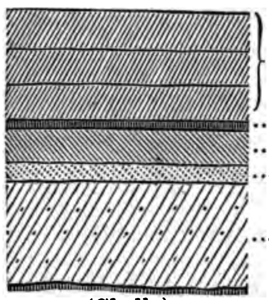
Proceeding first to Amiens I called upon Monsieur Pinsard, the learned architect and geologist, with whom I had been previously in correspondence, and received from him several

valuable hints respecting the most favourable localities for conducting my researches in.

Flint implements having been found most abundantly in a quarry near the convent of St. Acheul, within easy distance of the city, it was thither that I first directed my steps. The pits are worked for the fine gravel and brick clay they contain, and hence there are always numbers of workmen on the spot. On my arrival there I at once perceived how faithful are the descriptions and illustrations given by Mr. Prestwich and other learned geologists who have visited the locality in question, and hence I experienced little difficulty in determining the order and succession of its various strata.

The annexed drawings of sections in this quarry will give some idea of its most characteristic features.

No. 1.



Three beds of marl and clay, each about 19½ feet in depth.

...Bed of small flints, from 4 to 7½ inches.

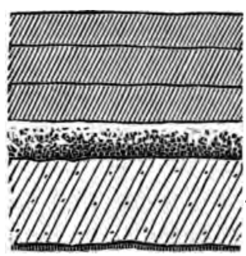
...Clay and marl, 19 inches.

...Sand and marl, about 12 inches.

...Bed of flints in which axe and arrow heads are found, 6 feet 2 inches.

(Chalk.)

No. 2.



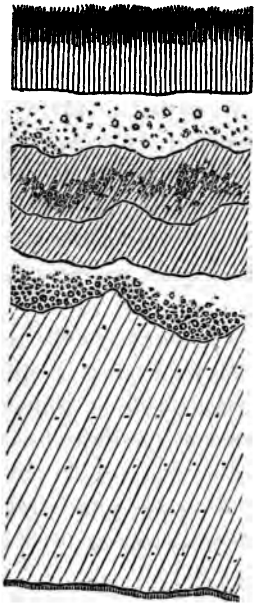
Three beds of marl and clay, each 19½ inches deep.

...Bed of small flints, 15½ inches.

...Flint nodules same as lowest bed in former section, 3 feet 8½ inches.

(Chalk.)

No. 3.



...Loam and clay, $39\frac{1}{4}$ inches.

...Bed of small flints, $26\frac{1}{2}$ inches.

...Marl and clay with flints, $26\frac{1}{2}$ inches.

...Another bed of clay and marl distinct from the overlying one.

..." Sable Aigre" mixed with flint gravel, 19 to 31 inches.

...Bed of flint nodules in which occur the remains of Elephas primigenius, Rhinoceros tichorrhinus, &c., and artificial flint weapons, (" haches,") about 9 feet 4 inches.

(Chalk.)

I was unsuccessful in discovering any worked flints myself, but obtained several very fair specimens from the workmen, and Monsieur Pinsard kindly presented me with some very fine and characteristic forms, on the genuineness of which I can implicitly rely.

I was fortunate in detecting a human skull rather low down in the brick earth, as I think in a somewhat unusual position, and one of the quarrymen informed me that such was the case. I disinterred and brought it to England. It is probably of Gallo-Roman type, but I have not as yet had it examined. Professor Goodsir, of Edinburgh, has, however, kindly promised to report upon it, and I hope to have the pleasure of bringing the subject before you again on some future occasion.

On reaching Abbeville, I of course made a point of calling

upon Monsieur Boucher de Perthes, and of visiting his most interesting museum. His collection of flint implements is very extensive, and includes specimens from all parts of the world, and many forms from the valley of the Somme besides those with which we are most familiar. It is, perhaps, only the practised eyes of the antiquary that could at first discover the artificial character of very many of these objects, but when once initiated, all appeared perfectly simple and easy to me. M. B. de Perthes took the greatest pains to explain to me his theories on the subject of the various uses to which these instruments have been applied, and I could not but admire the excessive ingenuity of his arguments. What strikes one immediately on examining such a collection as that of M. de Perthes is the constant recurrence of certain typical forms, which, of course, disposes at once of the question as to whether they have been produced naturally or artificially. The following are the conclusions to which I have come with regard to this interesting inquiry, after visiting and examining several sections in the Valley of the Somme:

1st. That these regularly-shaped and chipped flints, so clearly distinguishable from the other flints with which they are associated, bear about them indubitable marks of design, and may fairly be considered as the work of the earliest human inhabitants of the district in which they are found.

2nd. That the deposits in which they occur are undisturbed, as is clearly proved both by the character of the deposits themselves and the position in which the flints are found.

3rd. That the presence of remains of various extinct organisms does not necessarily prove their coexistence with man. They may have been coeval, and probably were, but this fact cannot be conclusively proved.

4th. That these superficial deposits in the Valley of the Somme are of post-glacial age.

Nothing definite can at present be stated respecting them

further than "that the various strata have been deposited under dissimilar circumstances," during alternate periods of disturbance and repose, not necessarily lengthened, probably extremely brief.

ON THE THICKNESS OF THE BUNTER AND KEUPER FORMATIONS IN THE COUNTRY AROUND LIVERPOOL.

By GEORGE H. MORTON, F.G.S.

The author gave the results of recent measurements of the Triassic strata around Liverpool, and exhibited a section of the Keuper Sandstone of Storeton and Wapping tunnel. The following shows the results that he had obtained:

KEUPER FORMATION.		
Red Marl	100	feet.
*Upper Shales, or Waterstone	75	,,
Upper Sandstone, red and yellow...	150	,,
Lower Shales	50	,,
Lower Sandstone, yellow and white, with conglomerate base	175	,,
BUNTER FORMATIONS.		
Upper soft yellow Sandstone	100	,,
Upper soft red and variegated Sandstone	300	,,
Pebble-beds	350	,,
†Lower soft red and variegated Sandstone, base yellow	400	,,
	1700	,,

* The Upper Shales may be above 75 feet; that is the apparent thickness.

† The Lower soft red and variegated Sandstone may possibly exceed 400 feet, for its actual base is not seen.

ABSTRACT

OF THE

PROCEEDINGS

OF

The Liverpool Geological Society,

SESSION THE FOURTH,

1862–63.

LIVERPOOL:
C. TINLING, PRINTER, DAILY COURIER OFFICE, CASTLE STREET.

1863.

OFFICERS, 1863.

PRESIDENT.

THE REV. PROFESSOR HENRY GRIFFITHS.

VICE-PRESIDENT.

HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S.

HONORARY SECRETARY.

GEORGE H. MORTON, F.G.S.

COUNCIL.

THOMAS J. MOORE, Cor. Mem. Z.S.
WILLIAM S. HORTON, F.G.S.
FREDERICK P. MARRAT.
EDWARD B. FRANCEYS.
SAMUEL B. JACKSON.
GEORGE THOMAS.

ABSTRACT OF THE PROCEEDINGS

OF THE

Liverpool Geological Society.

SESSION FOURTH.

OCTOBER 14TH, 1862.

HENRY DUCKWORTH, Esq., F.G.S., F.L.S., F.R.G.S., in the Chair.

ROBERT BOSTOCK and JOHN TYERMAN were elected Ordinary Members.

The following communication was read :

ON THE ANCIENT GLACIERS OF SNOWDON.

BY GEORGE H. MORTON, F.G.S.

THE author gave an account of two days he had spent on Snowdon, and minutely described the group of mountains known by that name, the highest peak—Pen Wyddfa—being 3,571 feet above the sea. The strata at the summit consist of felspathic ashes, and contain Bala fossils ; lower down felspathic porphyries prevail. There are six deep valleys on the flanks of Snowdon ; four of them contain lakes, supposed by Professor Ramsay to occupy the beds of ancient glaciers, where the rocks have been hollowed and scooped out by the ice. In all these valleys, as well as in the Pass of Llanberis, the evidences of glacial action are abundant, while in Cwm Llydaw, 1,800 feet above the sea, the hard igneous rocks are often so polished as to reflect the sun's light from their shining surfaces. At a greater elevation than 2,000 feet there is no *drift*, so that the strata are exposed in bold and broken masses.

NOVEMBER 11TH, 1862.

HENRY DUCKWORTH, Esq., F.G.S, F.L.S., F.R.G.S., in the Chair.

JOSEPH HILES, WILLIAM BURKE, ROBERT A. ESKRIGGE, JOHN E. KNEESHAW, D. J. TOUZEAU, THOMAS J. PARIS, and ISAAC ROBERTS, were elected Ordinary Members.

The following communications were read:

ON SCROPE'S THEORY OF VOLCANOS.

BY HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S.

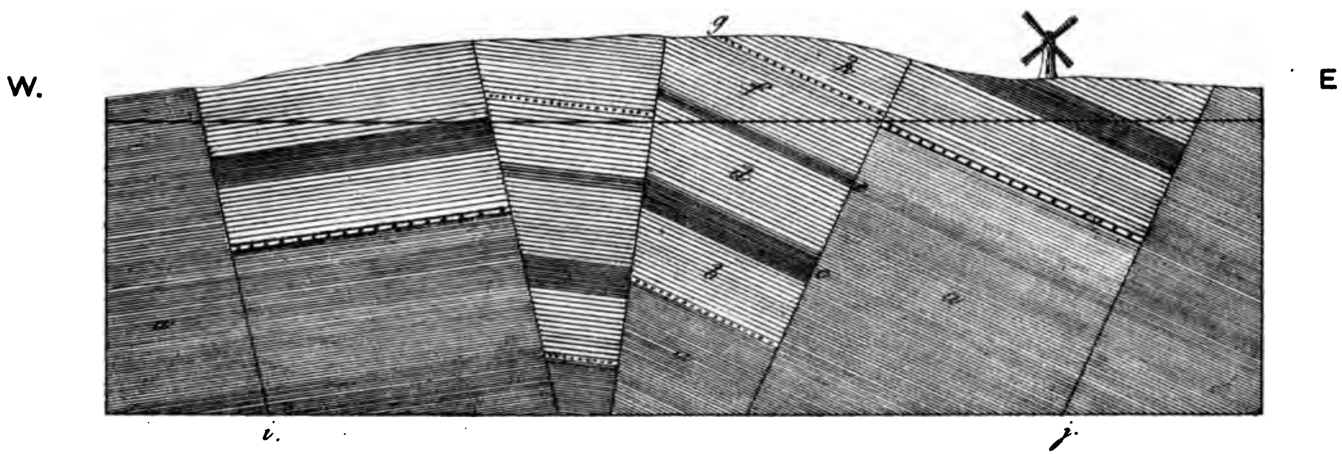
ON THE LINGULA FLAGS AND THE STRATA BENEATH.

BY GEORGE H. MORTON, F.G.S.

The author described at considerable length the principal localities in Europe and North America where the Lingula Flags and Lower Llandeilo strata are developed, and gave lists of the fossils found at Shelve in Shropshire, Bangor, Tremadoc, Malvern, Skiddaw, Dumfries, Sunderland, Bohemia, and North America.

In conclusion, he stated that "the fossils of the Lingula Flags embraced many varieties of form, and that though there were cosmopolitan species, there were others of more limited range in space. The result of geological investigation in the Cambrian rocks has brought to light but very scanty traces of early life. It being only in the strata of that age at Church Stretton and Bray Head that any such indications have been found. It is, however, remarkable that crystalline limestone should occur in the still lower Laurentian System, for if this rock was formed, like other limestones, of comminuted fragments of shells and corals, since altered by a high temperature, then the theory of such rocks being *azoic* is groundless, and we have yet to become acquainted with the most ancient creation."

SECTION THROUGH THE LOWER KEUPER SANDSTONE AT STORETON, CHESHIRE.



h Upper Stratum 36 feet
g Footprint Bed 3 "
f, Building Stone 33 feet.
e Red Clay 2 .
c, Shale & Clay 14 feet.
b. Basement Bed 30 .

DECEMBER 9TH, 1862.

THE PRESIDENT, THE REV. PROFESSOR HENRY GRIFFITHS, in the Chair.

J. P. LAMB was elected an Ordinary Member.

The following communications were read;

REPORT OF THE SOCIETY'S FIELD MEETINGS AT STORETON AND LEASOWE.

BY GEORGE H. MORTON, F.G.S.

A field meeting was held at Storeton, on Monday, the 7th of July, 1862. The author exhibited for the first time a section drawn to scale, showing each important bed that occurs in the oldest of the Storeton quarries. It is the south quarry, close to the mill. The interesting faults, and the position of the Keuper Sandstone, in a fissure of the Bunter Sandstone, cause the section to be very remarkable and instructive. The annexed lithograph of it is taken from Mr. Morton's work on "The Geology of the Country Around Liverpool," just published by the Liverpool Naturalists' Field Club.

A field meeting was also held at Leasowe, September 20th, 1862.

Mr. Morton conducted the members to the interesting sections of the submarine Forest Beds at Leasowe Lighthouse and Dove Point.

The following lithographs are from the before-mentioned work:

Descriptions of the annexed sections along the Cheshire coast, from the Lighthouse to Dove Point, Leasowe:

15a. Section from the Lighthouse along the embankment to Dove Point.

k. Leasowe Lighthouse.

j. Ditto Embankment.

i. Dove Mark.

h. Hills of Blown Sand.

g. Sandy earth, with recent shells, bones, and teeth, 2 feet.

f. Peat bed, 1 foot.

e. Blue Silt, 1 foot.

d. Submarine Forest Bed, with portions of trees. The surface where the antiquities described by Dr. Hume were found. 3 feet.

c. Blue Silt, traversed with vegetable fibre. No trace of pebbles. 2 feet 6 inches.

b. Submarine Land Surface, with a few remains of trees. 1 foot.

a. Boulder Clay.

15b. Section at the Lighthouse, at a right angle to the former.

h. The sea shore, covered at high water.

g. Leasowe Lighthouse.

f. Ditto Embankment.

e. Old clay pit, near the Lighthouse.

d. Present surface of the land, 1 foot.

c. Drift Sand, 2 feet.

b. Submarine Forest Bed, 2 feet,

a. Boulder Clay.

15c. Section from Dove Mark across the shore towards the sea.

j. The shore, covered except at low water.

i. Dove Mark.

h. Sand hills.

g. Sandy earth, with recent shells, bones, and teeth, 2 feet.

f. Peat bed, 1 foot.

e. Blue Silt, 1 foot.

d. Submarine Forest Bed, with portions of trees. The surface where the antiquities described by Dr. Hume were found. 3 feet.

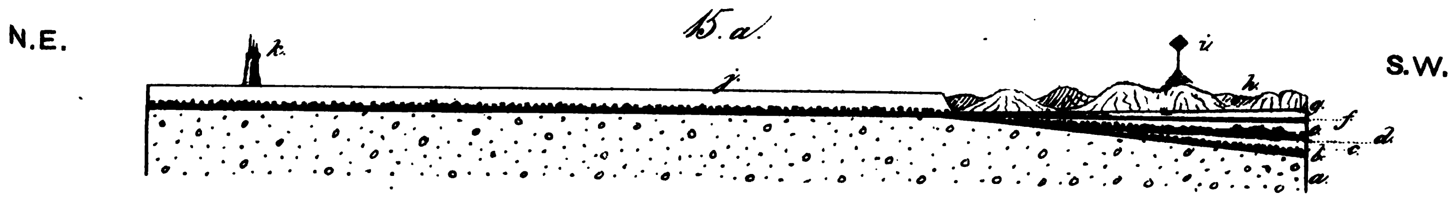
c. Blue Silt, traversed with vegetable fibre. No traces of pebbles. 2 feet 6 inches.

b. Submarine Land Surface, with a few remains of trees. 1 foot.

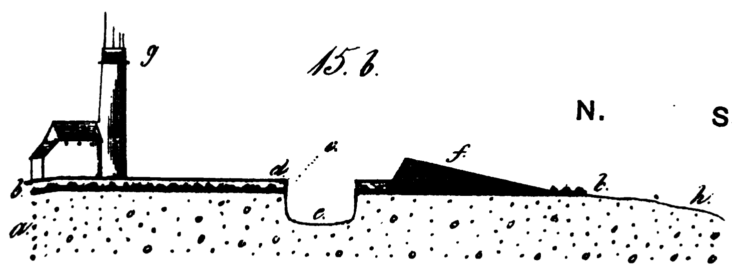
a. Boulder Clay.

Each of the beds was described, and the lines of the sections traversed.

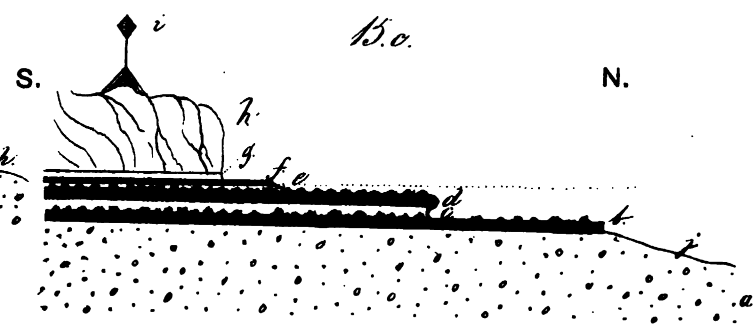
SECTIONS ALONG THE CHESHIRE COAST FROM THE LIGHTHOUSE, DOVE POINT, LEASOWE.



FROM LEASOWE CASTLE TO DOVE POINT.



AT LEASOWE LIGHTHOUSE.



AT DOVE POINT.

ON THE GEOLOGY OF THE THAMES VALLEY.

By WILLIAM S. HORTON, F.G.S.

The physical features of the district consist of a succession of low terraces overlooking the Valley of the Thames, or Isis presenting to the course of that river their more abrupt flanks, and gently sloping down in the opposite direction. This terrace-like succession is a true index to the stratigraphical structure of the district, as it will be found that each of them is composed either of Limestone or some other firm rock, resting upon a basis of clay, which forms the intervening valley. The formations occupying the tract of country described in this paper are in descending order; the Post Pliocene, (represented by the high-level gravel and the Estuarine, or low-level gravel;) the Lower Cretaceous, (the Shotover Sand and Lower Green Sand;) and the Upper and Middle Oolites, consisting of the Purbeck Beds, Portland Stone and Sand, Kimmeridge Clay, Upper Calcareous Grit, Coral Rag, Lower Calcareous Grit, and Oxford Clay. The Oxford Clay occupies a considerable area, extending northward from the ridge of the Coral Rag, but, as for the most part it is level ground, and generally covered by the Estuarine gravel, but very few sections occur. Its thickness is very considerable; at Wytham Hill it was ascertained from a boring to be 600 feet, it is, however, probable that thickness is somewhat exceptional, as at St. Clement's, on the other side of Oxford, it is reduced to 265 feet. Crystals of selenite and iron pyrites occur, but fossils are by no means plentiful, and only locally preserved. The Coral Rag and its associated beds, the Upper and Lower Calcareous Grits, form a low terrace, rising somewhat abruptly from the low ground of the Oxford Clay, and overlooking the Valley of the Isis. In a large quarry at Kingstone Bagpuze the Upper Grit may be observed resting on the Coral Rag, which in its turn reposes on the Lower Grit. At Wheatley, to the northeast of Shotover, these beds form an anticlinial, or dome, dipping under the Kimmeridge Clay, in every direction from the centre. The Coral Rag in this neigh-

bourhood contains its usual assemblage of Zoophytes and Echinoderms. The Kimmeridge Clay extends along a band of country following the course of the Coral Rag, and resting upon the southerly slope of the terrace formed by that rock. Its organic remains do not offer any important differences from those of the Oxford Clay, indeed many of them are common to both formations. The best sections of the Kimmeridge are at Headington, near Oxford, and Culham, near Abingdon. The Portland beds extend in a narrow band round the Shotover ridge of hills. At Combe Wood, near Cuddesden, a small patch of Purbeck beds may be observed resting on the Portland Stone. They consist of about four feet of grey marly Limestone, containing *Cypris*, *Mytilus*, and *Paludina*. At Culham the Gault and Lower Green Sand may be observed reposing on a base of Kimmeridge Clay. The Gault at this place is a blue laminated clay, with its characteristic fossils, *Ammonites lautus*, *A. interruptus*, *Nucula pectinata*, *Inoceramus*, *concentricus*, and *Plicatula pectenoides*. The Lower Green Sand contains no fossils in the neighbourhood of Oxford, but at Faringdon the remarkable gravels of this age are almost entirely composed of sponges, Bryozoa, and Mollusca. The fresh-water sands of Shotover have been the subjects of essays by several writers, who all agree as to their fresh-water origin, but are not so unanimous as to their geological date, some being inclined to regard them as being the equivalent of the Hastings Sands, or Wealden beds, and others as an estuarine condition of the Lower Green Sand. Professor Phillips is of the latter opinion, and it seems to be the safer course to regard them as an exceptional condition of the Green Sand. They contain very few fossils; those that have been collected belong to the genera *Paludina*, *Cyrena*, *Unio*, and *Cypris*. These beds are valuable, as producing the well known Oxford Ochre. The high-level gravel belongs to the period of the northern drift, and is so called because it occupies the highest ground in the district, as at Wytham Hill, where it attains an elevation of 583 feet above sea level. It does not contain any organic remains, and is composed of well rounded quartz pebbles.

The low-level gravel is quite distinct in its origin, being formed almost entirely of local rocks, and containing water-worn Oolitic fossils, such as *Terebratulæ*, and fragments of *Belemnites*. South of Abingdon, where the surface rocks are cretaceous, it passes into a flint gravel, evidently derived from the denudation of the chalk of the district. The only remains belonging to the period when it was deposited are those of elephants, probably *Elephas primigenius*. From the position of this gravel, which extends into the Valleys of the Windrush and Evenlode, and other tributaries of the Thames, we may conclude that it was formed at a comparatively recent period, when the ridges of Coral Rag were dry land, and what are now river valleys were a series of shallow lochs, similar to those on the west coast of Scotland.

JANUARY 13TH, 1863.

THE PRESIDENT, THE REV. PROFESSOR HENRY GRIFFITHS, in the Chair.

A. NORMAN TATE, F.C.S., was elected an Ordinary Member.

ADDRESS OF THE PRESIDENT.

He referred at length to some interesting geological phenomena, peculiar to North and South Wales, with regard to the Old Red Sandstone, and particular attention was drawn to that system of strata. The President then minutely described the series of fossil ichthyolites of that age, lately added to the collection of the Royal Institution.

The following communication was read:

ON THE WIGAN COAL FIELD.

BY S. B. JACKSON.

The area treated of was illustrated by Farrimond's valuable mining map and list of strata. These served also to indicate the multitudinous "faults" and dislocations of the district, and

the "cutcrops" of the numerous seams of coal by which it is enriched. The Wigan Coal Field contains the Lower and Middle Series of the Lancashire Coal Measures. The former are thrown up at Billinge and Up-Holland, present a lofty range of hills, and divide the Wigan from the St. Helens Coal Field. With this exception, the superficial aspect of the region is undulating, and presents no remarkable natural feature. The Millstone Grit constitutes the lowest known rock in the district, and the portion exposed at Grimshaw Delf is about 100 feet thick. Resting upon it are the Lower Coal Measures, 1,800 feet in thickness. They consist of a series of micaceous flags, shales, and thin beds of coal, with their floors of under clay, containing Gannister, a peculiarly hard silicious stone, which, in the first instance, gave the name of "Gannister beds" to the series in which they are found. They contain six seams of coal, designated "Mountain Mines," having an aggregate thickness of about nine feet. Only two of the seams have been found worth working, and those to a limited extent. The sandstones of this series are even-bedded, showing ripple marks and sun-cracks, and are very extensively used for flagging and roofing purposes, splitting along planes, formed of micaceous flakes. A good section of the Lower Measures may be seen in the cutting of the Lancashire and Yorkshire Railway between Pimbo-lane and Up-Holland Stations. Resting upon the micaceous flagstones just referred to is the base of the Middle Coal Measures, which attain a thickness of about 2,400 feet. They consist of an alternating series of reddish, grey, and yellow sandstones, shales of various character, and beds of coal, with their under clay. This series is the most prolific of coal, containing not less than forty-five seams, with an aggregate thickness of 100 feet. Two-thirds of the number of seams, ranging from two to thirty-two inches, with a total thickness of thirty-three feet, are either impure or too thin to pay for working. The remaining fifteen seams contain about sixty-seven feet of coal, and are those which are exclusively worked in the Wigan Coal Field. These range from about two to ten feet in thickness. The properties and qualities of

the respective seams of coal differ considerably, as do also remote and detached areas of the same seam. Generally speaking, the whole may be grouped into three classes, viz., the Free-burning, the Bituminous, and the Cannel Coals, of each of which this field furnishes an ample and excellent supply. As a rule, the seams which exceed four feet in thickness are inferior in value to those which are four feet or under, and in most cases the quality near the outcrop is not so good as on the deep. The most valuable seam in this series is the Cannel Coal, and next to it the Orrell Four Feet, or Arley Mine, which at Wigan closely resembles the famous Wallsend of the Newcastle Field. This seam being the lowest, is sometimes worked at a great depth. At the centre of the Wigan basin, (say under Wallgate,) it is about 863 yards from the surface. Our limits preclude a particular description of the several seams. Notwithstanding differences of thickness in strata, and of the quality of the various seams of coal in the two districts, there exist such analogies between the coal beds of Wigan and those of St. Helens that miners entertain no doubt of their identity. Indeed the prevalence of a thick bed of *Anthracosia robusta,* commonly called the "Cockle-shell Bed," occurring upon a substratum of under clay, about sixty feet above the Arley Mine, taken in conjunction with the nearness of the Gannister beds below, enables the geologist to identify the strata at the base of the Middle Coal Measures of Lancashire wherever they occur.

A series of great "faults," or dislocations, running almost parallel with each other in a N.N.W. direction, and nearly equidistant, divide the Coal Field of Wigan into a succession of belts. Minor faults branch away from the main faults in all directions, and break up the strata into numerous sub-divisions. Moreover, each fault and branch fault has a certain and considerable inclination to one side or another in its course, varying from one to three vertical to one horizontal. Hence every locality requires to be "proved," either by boring, or by the sections of adjacent collieries, so that in sinking a shaft the miner may avoid faults, and "win" at the least

outlay, the greater number of seams of coal. The forces which occasioned the dislocations have diminished in power northwards, and the extent of their "upthrows" and "downthrows" vary over the field in question from a few yards to upwards of six hundred. The effect of great upthrows has been the loss of many valuable seams in some localities, and that of downthrows to preserve them, while their combined result has been in one part of the field or another to cause every seam to have one or more "cutcrops." The courses of these "cutcrops" are clearly traced on the recently coloured maps of the Geological Survey, and some of the most favourable situations for viewing them, as well as sections of the district, are given in the memoirs of that survey, by Mr. Hull. The coal bed roofs of the Lower Measures of Wigan include remains of drifted plants and *Sigillaria*, and, in the under clays, *Stigmaria*. The "floors," or under clays, of the coal beds of the Middle Measures abound with *Stigmaria*, or roots of *Sigillaria*, the stems of which occasionally intersect a coal bed, but are generally found in the roof. Especially is this the case in the roof of the Four Feet Ince Mine, where, from their upright position and ponderous weight, and the nature of the roof itself, they are the frequent cause of melancholy accidents. The coal beds themselves are vast depositories of fossil vegetation, whose forms and tissues are for the most part obliterated; but in the roofs are found, beside *Sigillaria*, numerous Ferns, *Asterophylites*, *Calamites*, *Lepidodendrons*, and *Coniferæ*.

The Fauna of the Lower Coal Measures of Wigan furnish *Anthracosia*, *Modiola*, *Goniatites Listeri*, and *Aviculo-pecten papyraceous*. In the roof of the Lower "Mountain Mine" is a fish bed, containing bands, full of *Cypris* or *Cythere*, *Microconchus*, *carbonarius*, *Anthracosia*, and more rarely *Goniatites*, fish bones, scales, teeth, &c.

The Middle Series contain *Anthracosia robusta* in abundance, and the varied remains of two fish beds, one over the Arley and the other over the Cannel Mine.

From Mr. Hull's memoirs we learn also that the late Mr. Peace, mining agent to the Earl of Balcarres, collected

from the latter bed beautiful specimens of fish, of the genera *Megalicthys*, *Holoptychius*, *Diplopteris*, *Ctenoptychius*, and some large dorsal rays.

Some idea of the immense value of this Coal Field may be deduced from Mr. Hunt's Mineral Statistics for 1861. He gives the total quantity of coals raised that year in the United Kingdom as 83,635,214 tons, of which 12,195,500 tons were raised in Lancashire. The number of collieries (not pits) then in Lancashire was 375, the proportion in the Wigan district being 78. An uniform average quantity for each colliery would show the produce of the Wigan Coal Field that year to be about 3,000,000 tons. Eight shillings per ton at the pit's mouth, a low enough estimate for Cannel and all sorts, would give £1,200,000 as the produce of the mines for one year. The facilities at some of the Wigan collieries for executing extensive orders for shipment in a very short time are surprising. At Rose Bridge Colliery, for instance, the property of Messrs. Case and Morris, Mr. Bryham, the able and obliging manager, states they can raise with ease a thousand tons per day, or fifteen hundred tons in the twenty-four hours, by working night and day.

FEBRUARY 10TH, 1863.

THE PRESIDENT, THE REV. PROFESSOR HENRY GRIFFITHS, in the Chair.

JOHN PEPPER was elected an Ordinary Member.

The following communications were read:

ON THE PRIMITIVE ROCKS.

BY FREDERICK P. MARRAT.

ON THE GEOLOGY OF THE EGYPTIAN DESERT.

BY HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S.

ABSTRACT.

Egypt, with its desert tracks, covers an area of about 100,000 square miles. In form it is an irregular parallelogram, the longest axis of which runs North and South. It is situated between 24° and 32° North latitude and 27° and 31° East longitude. On the North it is bounded by the Mediterranean Sea, on the East by the Red Sea and the Isthmus of Suez, on the South by Nubia, and on the West by that vast sterile region, the Sahara.

It is that desert tract East of the Nile that I purpose making a few remarks upon in the present communication, the region generally known as the "Egyptian Desert," and which, from its connexion with the Overland Route and the Suez Canal scheme, has had, and is still likely to have, more than an ordinary amount of attention directed to it.

The desert which stretches between Cairo and Suez is more varied in aspect than those who are unacquainted with it might be disposed to believe, the ground being everywhere broken up into a series of undulating tracts, or shallow ravines, called by the Arabs "*Wadis*," whilst the mountain ranges of Jebel Mukattam, Jebel Reibun, and Jebel Attakah, form a complete barrier towards the South.

The surface of the land presents generally the appearance of a gravelly beach, pebbles and angular fragments of jasper, chert, quartz, gypsum, and sandstone being largely intermingled with the sand.

Vegetation is not altogether absent, and in the Wadis several ligneous and herbaceous plants are found, among which are the *Acacia Egyptiaca*, the *Astralagus Hamosus*, and the *Fagonia Latifolia (Sieberi et tumidus.)*

*   *   *   *   *   *   *

The height of the desert varies considerably, but its extreme elevation above the sea may be stated at about 700 feet. Its

general character is that of an elevated plateau, rising towards the centre and gradually sinking until it terminates in bold escarpments on the banks of the Nile on one side and on the shores of the Red Sea on the other.

* * * * * * *

These cliffs are composed for the most part of Nummulitic Limestone, which we find extensively developed throughout Egypt and Nubia and a great part of the Sinaitic peninsula.

Overlying this Limestone are patches of a Sandstone formation, associated with Calcareous Gypsums and Saline Marls, and stretching from the Mediterranean Sea far into the Nubian and Libyan deserts.

The absence of its beds at certain points has evidently been caused by denudation, and the sands and gravels of the desert may be regarded as the *débris* of this formation.

The beds of this Sandstone vary in thickness from a few inches to 180 to 200 feet.*

* * * * * * *

Silicified Monocotyledonous wood is found in great abundance in this deposit, especially in the vicinity of Cairo, where the remains are so well preserved and of such magnitude as to be popularly known as the "Petrified Forest."

The wood stems in question are invariably found in a horizontal position, and there is no evidence to show that they originally flourished *in situ*.

Professor Unger, of Vienna, states that the trees belong without exception to one species, for which he proposes the provisional name *Nicolia Egyptiaca*; and further, that the Sandstone in which they occur is strictly analagous to a formation containing wood stems near Gleischenburg, in Styria. He supposes the masses of wood to have been drifted into a basin separated from the main sea, and filled with water saturated with silica—a hypothesis which appears to me extremely probable.

* Newbold.

ON THE COMPOSITION OF BLACK SANDSTONE OCCURRING IN THE TRIAS AROUND LIVERPOOL.

BY A. NORMAN TATE, F.C.S.

The following remarks refer to certain deposits of a black colour found in the Sandstone of Flaybrick, Storeton, Toxteth Park, and other places.

My attention was directed to these deposits by Mr. G. H. Morton, F.G.S., and I have since examined them chemically to ascertain their composition. On treating them with Hydrochloric Acid, Chlorine Gas was evolved, and the dark coloured portion dissolved, leaving a residue of white sand. A quantitative analysis showed that, next to Silica, the principal ingredient was Peroxide of Manganese. One sample contained as much as 10 per cent. of that substance, whilst in others the quantity did not exceed 3·5 per cent. To the presence of this Peroxide of Manganese the black colour is evidently due. It does not exist throughout the entire mass, but merely coats the grains of sand. As far as I have yet noticed these deposits they appear to occur most frequently in bands of from ¼ inch to a mere line in thickness, but they are also found distributed in patches and small lumps throughout the mass of the rock. In several pieces I have collected, the black sandstone is distributed much in the same manner as the currants in an ordinary currant cake.

The deposits I have described must not be confounded with other dark coloured portions of the sandstone. Some sandstones undoubtedly owe their dark colour to the presence of organic matter. This organic matter is derived from the overlying vegetable mould, whence it is extracted by water and conveyed to the rocks beneath.

In some dark coloured sandstones Protoxide of Iron may also be found.

MARCH 17TH, 1863.

THE PRESIDENT, THE REV. PROFESSOR HENRY GRIFFITHS, in the Chair.

WILLIAM FEARNALL was elected an Ordinary Member.

The following communications were read:

DESCRIPTION OF THE FOOTPRINTS OF CHEIROTHERIUM AND EQUISETUM, FOUND AT STORETON, CHESHIRE.

BY GEORGE H. MORTON, F.G.S.

The author referred to the original description of the Cheirotherium footprints found at Storeton, as given by John Cunningham, Esq., F.G.S., in 1838. He stated that no specific name had been assigned to it, and proposed the provisional one of *Cheirotherium Storetonense.* It is the smallest of the following three, from different places in Cheshire.

Cheirotherium	Hercules,	Tarporley.
Ditto	Kaupii,	Lymm.
Ditto	Storetonense,	Storeton.

About the time the footprints were discovered, the reed-like stem of a plant was found at the same place. Lithographs of both were published by the late Natural History Society of Liverpool. The fossil reed is now in the museum of the Royal Institution. It has been examined by Mr. F. M. Webb, who described it as the upper portion of an *Equisetum,* but without any remains of fructification. The stem is simple, sulcate, grooves 1¾ lines in breadth. The teeth of sheaths are triangular, measuring, when perfect, 1½ lines in length. It is drawn half the natural size, the specimen being about 14 inches long. In Professor Morris's catalogue of British fossils there is no species of the genus, but one from the Keuper of Wurtemberg is inserted. The author proposed the name *Equisetites Keuperina.*

ON THE ORIGIN AND PRACTICAL VALUE OF MARBLE.

By EDWIN STIRLING.

ON THE CORALS OF THE SILURIAN SEA.

By G. H. MORTON, F.G.S.

The author introduced his remarks by giving an outline of the arrangement of the Polypi, by Professor Milne Edwards and M. Jules Haime, in their monograph "On the British Fossil Corals." By means of specimens from his collection, and some recent species, he explained the general characters of each of the four important groups, viz.:

Zoantharia	aporosa.
Ditto	perforata.
Ditto	tabulata.
Ditto	rugosa.

In conclusion, he remarked "that if the great development of the septal arrangement in the Zoantharia indicates a higher organization of the Polyp, most of the Silurian Corals certainly belong to lower forms of that order than those common at the present time. We must, however, remember, that as we find the two sub-orders, *tabulata* and *rugosa* only, in the Devonian, Carboniferous, and Permian Systems, it cannot be said that the Silurian differs, except by the addition in its upper strata of *Palæocyclus;* and if we include that genus in the sub-order *Aporosa*, the coralline fauna as a whole is absolutely higher than that of any other more recent palæzoic epoch. If *Palæocyclus* really belongs to the family *Fungidæ*, it is very remarkable that no recurrence of the sub-order *Aporosa* has been noticed until after the close of the Palæozoic period."

"The earliest Llandeilo Corals known seem to belong to *Zoantharia tabulata*, and do not differ materially from those of the same sub-order in the Upper Silurian. *Pyritonema* is a peculiar genus, while *Heliolites catenularius* occurs from the Llandeilo to the Wenlock strata inclusive. No early examples of *Zoantharia rugosa* have been discovered, and it does not appear that the earliest forms of coralline bodies were the lowest of their order. Few and fragmentary, however, are the Corals of the Lower Silurian, and not even a trace has come to light from the still more ancient Cambrian, so that our knowledge after all is very scanty and uncertain about them."

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WELD, W., 12, Castle-street.

*WORTHY, G. S., 130, Vine-street.

YATES, G., 97, Byrom-street.

*Read a Paper or Papers before the Society.

ABSTRACT

OF THE

PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY,

SESSION THE FIFTH,

1863–64.

LIVERPOOL:
C. TINLING, PRINTER, DAILY-COURIER OFFICE, CASTLE STREET.
1864.

OFFICERS, 1864.

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THE REV. PROFESSOR HENRY GRIFFITHS.

VICE PRESIDENT.

HENRY DUCKWORTH, Esq., F.G.S., F.L.S., F.R.G.S.

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GEORGE H. MORTON, F.G.S.

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SAMUEL B. JACKSON.
ROBERT A. ESKRIGGE.
HUGH F. HALL.

ABSTRACT OF THE PROCEEDINGS

OF THE

Liverpool Geological Society.

SESSION FIFTH.

OCTOBER 5TH, 1863.

THE PRESIDENT, THE REV. PROFESSOR GRIFFITHS,

in the Chair.

After the Council had been elected, the Honorary Secretary read a Report of the Society's progress during the past twelve months, in which he referred to its successful scientific career, and satisfactory financial position.

The following communication was read:

ON THE LOWER LIAS AND AVICULA-CONTORTA BEDS OF GLOUCESTERSHIRE.

BY GEORGE S. WORTHY.

The author illustrated his remarks by good sections of the strata at Aust Cliff and Westbury, and by numerous fossils from the different zones of strata at each of those localities.

NOVEMBER 10TH, 1863.

THE PRESIDENT, THE REV. PROFESSOR GRIFFITHS, in the Chair.

EDWARD W. BINNEY, F.R.S., F.G.S., and WILLIAM BRYHAM, were elected Honorary Members.

BRICE M. WRIGHT, HUGH F. HALL, D. C. DAVIES, and CHARLES RICKETTS, M.D., were elected Ordinary Members.

The following communications were read:

ON THE LIAS FORMATION AS DEVELOPED IN SHROPSHIRE.

BY GEORGE H. MORTON, F.G.S.

Geologists will remember that Sir R. I. Murchison described in the "Silurian System" a district of Liassic country, in the north of Shropshire, and that an oblong tract is so coloured in all recent geological maps of England. A very concise account of the district is given in the great work referred to, but no other notice has been published regarding it. The occurrence of such a fossiliferous formation only forty miles from Liverpool is in itself an interesting fact, while the details deserve the attention of the Society.

Like many parts of the south of Cheshire, the north of Shropshire is very deeply covered with drift, composed of sand, gravel, and boulder clay. The country has an undulating surface, whether the rock beneath be Lias or Red Marl. The whole extent of the Lias is supposed to be represented by an area ten miles long by about four and a half in breadth, the greatest direction being N.E. by S.W., as indicated on the maps of the Geological Survey.

When Sir R. I. Murchison examined the country, thirty years ago, there seem to have been greater facilities

than now for seeing the strata exposed. There were then several borings being rigorously carried on in search of coal; in fact, it was that circumstance that led to his visiting the neighbourhood.

The Liassic strata were pierced at Heathgate, Moreton Wood, Prees Wood, Calvin Wood, Burley Dam, Marchamley, Cloverley, and Wolliston Common, all places indicated on the map of the district. The greatest depth would appear to have been reached at Wolliston, where, at four hundred feet, a little lignite was found, but nothing resembling a bed of coal.

The section represents the Lias and underlying Red Marl, across the district from west to east, through Prees Hill, and shows the structure of the country. All the borings seem to have been made in the Lower Lias, which has always a slight resemblance to coal shale. At Lightfoot's-green the shale was found to contain nodules of ferruginous cement stones, and a bed of white rock and others of the ordinary blue colour were found to extend from Burley Dam south as far as Cloverley, where the Lias dips west, indicating the strike of the beds to be due north and south. The drift was sometimes found to be twenty or thirty yards in thickness. At Burley Dam there was formerly a quarry for slating purposes, and in the same locality bituminous matter, similar to Kimmeridge coal, was found. The Lower Lias is said by Murchison to be exposed between Prees and the Hawkstone Hills to the south east, but there seems to be no exposure now. The geological surveyors have coloured a narrow space in that direction as Red Marl, which should be Lias, according to Murchison, who mentions a boring in the latter formation as having been made at Marchamley. There is now no rock to be seen there, for the country is covered with drift, so that the locality is not so favourable for observation as formerly.

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In the "Silurian System" there is a list of fossils, and it is singular that in addition to numerous fossils well known in the Lias of Yorkshire and the west of England, there are some of the same species as at Brora, in Sutherlandshire. This Lias of Shropshire is sixty miles from the nearest part of the same formation in Worcestershire, and two hundred miles from that of the north east of Ireland, and the question very naturally arises, Was it ever connected with those districts, with the Hebrides, or with Brora, on the north east coast of Scotland? Perhaps it was separated by land from the most distant places, but connected with the formation in Worcestershire.

Near Burley Dam, at the north of the district, there is a brook section, a few yards west of Walk Mill. The strata are slaty, splitting into thin laminæ, which only contained a small bivalve shell, probably *Modiola minima*, but in considerable abundance. North of this locality is another brook section, where the Lower Lias again occurs under the word "very" of the sentence on the geological survey map, "very hard white and gray beds." The strata consist of hard, light coloured shales, but no fossils were discovered. If there be no unconformability between the Lias and the Red Marl, the passage beds of the two formations might be discovered in the brook which intersects the strata, but on the occasion of the author's visit there was no time to work out that interesting point. To the east of Burley Dam, about two miles from Brook's Mills, there is a very good section of the Red Marl; it consists of red, flaggy beds, with a few bluish spots and patches interspersed.

A section once was open in a brook about a mile to the south of the village of Audlem; after some delay in finding the precise spot, it was ascertained that the railway embankment of a new line had covered it entirely from view. The place is named Cock Bank in the Ordnance map. One mile to the north west, beyond Butterly Hey, there is a surface section along the bottom of a ditch. The rock is a hard, black shale, and contains several fossils, but they seem to be dwarfed specimens, and being generally much broken, it would be rather difficult to ascertain the species of Lima, Pecten, and other shells that occur there.

Ascending the hill at Prees, which is about a mile and a half from the station, thick strata of yellow sandstone were observed on the left hand side of the road. Belemnites occur there, and there are many holes in the rock, out of which they have fallen. The only quarry—that already referred to—is over the hill to the right of the church. The place is known as the "Yew Chair," from an old yew tree whose old trunk hanging over the quarry has a rude resemblance to a chair. The quarry is to the south of the church, on the slope of the hill, the bank or escarpment being about thirty feet. At first sight it presents much the appearance of boulder clay, in consequence of the strata being argillaceous and rotten, but in reality it is a good section of the Marlstone, or middle division of the Lias. Many fossils were here obtained, but only the species of a few have been determined, namely, *Ammonites Geometricus* and *Pecten æquivalvis.* Two species of *Avicula,* two species of *Belemnites,* and several bivalve shells also occur.

About twelve months ago a boring for coal was made in the Lower Lias, where it crops out from under the Marlstone, about half a mile from the Yew Chair, and had been abandoned a short time before my visit. It seems probable that persons will always be found foolish enough to search for coal in any black looking shale, whether it be Lias-

shale, Silurian-shale, or any other rock presenting the slightest resemblance to coal shale. Previous to boring, a shaft was sunk, and from the weathered shale and limestone nodules several fossils were obtained.

In conclusion, with regard to the co-ordination of the Lias of this district with that of Yorkshire and the west of England, it is evident that the three leading divisions are common to each. Before visiting Shropshire it was hoped that the base of the Lower Lias might be visible, and that there was a possibility of identifying what are known as the Rhætic beds, but the foregoing remarks will have shown the impossibility of doing so by means of any sections now visible.

The outline of the district has been determined, partly by the trial pits for coal, and partly by the few open sections that have been described, so that although it is far from satisfactory, it is probably the best that can be made out. The sections described are most likely all that are now exposed, and the country around being so deeply covered with drift, it will be difficult to obtain further information with regard to its stratification.

REPORT OF THE FIELD MEETING AT CASTLETON, DERBYSHIRE.

JULY 10TH AND 11TH, 1863.

BY R. A. ESKRIGGE.

The excursion was made under the guidance of W. S. Horton, F.G.S., who described the geological features of the district. Nearly the whole of the surrounding country is occupied by the lower members of the Carboniferous formation. The high ridge of hills to the north and west of Mam Tor, known as the High Peak, is composed of Millstone Grit, which rock in Kinderscout attains an

elevation of 1,900 feet above the sea level. Mam Tor, or the shivering mountain, is composed of shales (the equivalents of the Yoredale rocks of Yorkshire) resting upon the Mountain Limestone. The lower beds are charged with bitumen, which has probably been derived from the denuded coal measures. The mineral was observed in the Blue John Cavern. The most remarkable feature of the Mountain Limestone is the occurrence of the singular caverns which impart to the rock so much of its interest. These were concluded to have been produced by the long continued percolation of water through what were originally narrow joints or fissures. An examination of the immense chasms known as Cave Dale and the Wynnats, leads to the conclusion that they were formerly caverns that have had the overlying rock denuded and their roofs removed.*

The caverns, of which the more remarkable are the Peak and the Blue John, present every evidence of having been channeled out by the action of running water. This agency is still partially in operation, as in the case of the Peak Cavern, from the mouth of which a considerable stream issues. The Mountain Limestone is traversed by veins of lead and zinc, the general direction of which is from east to west. The igneous rocks are represented in this neighbourhood by greenstone, which may be observed at the head of Cave Dale. Near this there is a mass of basalt in the columnar form. The appearance presented by Mam Tor, and the undulating surface presented by an immense mass of confused *débris* lying at the bottom of its precipitous escarpment, lead to the conclusion that there had been, long ago, a vast landslip, and that a portion of the mountain had been hurled into the valley below.* Many fossils were obtained, but as a full list has appeared in Mr. Taylor's Geology of Manchester, the publication of a part only would be useless.

* These explanations were advanced by Mr. Morton.

OFFICERS, 1864.

PRESIDENT.

The Rev. Professor HENRY GRIFFITHS.

VICE PRESIDENT.

HENRY DUCKWORTH, Esq., F.G.S., F.L.S., F.R.G.S.

HONORARY SECRETARY.

GEORGE H. MORTON, F.G.S.

COUNCIL.

FREDERICK P. MARRAT.
THOMAS J. MOORE, Cor. Mem. Z.S.
GEORGE S. WORTHY.
SAMUEL B. JACKSON.
ROBERT A. ESKRIGGE.
HUGH F. HALL.

ABSTRACT OF THE PROCEEDINGS

OF THE

Liverpool Geological Society.

SESSION FIFTH.

OCTOBER 5TH, 1863.

THE PRESIDENT, THE REV. PROFESSOR GRIFFITHS,

in the Chair.

After the Council had been elected, the Honorary Secretary read a Report of the Society's progress during the past twelve months, in which he referred to its successful scientific career, and satisfactory financial position.

The following communication was read:

ON THE LOWER LIAS AND AVICULA-CONTORTA BEDS OF GLOUCESTERSHIRE.

BY GEORGE S. WORTHY.

The author illustrated his remarks by good sections of the strata at Aust Cliff and Westbury, and by numerous fossils from the different zones of strata at each of those localities.

NOVEMBER 10TH, 1863.

THE PRESIDENT, THE REV. PROFESSOR GRIFFITHS, in the Chair.

EDWARD W. BINNEY, F.R.S., F.G.S., and WILLIAM BRYHAM, were elected Honorary Members.

BRICE M. WRIGHT, HUGH F. HALL, D. C. DAVIES, and CHARLES RICKETTS, M.D., were elected Ordinary Members.

The following communications were read:

ON THE LIAS FORMATION AS DEVELOPED IN SHROPSHIRE.

BY GEORGE H. MORTON, F.G.S.

Geologists will remember that Sir R. I. Murchison described in the "Silurian System" a district of Liassic country, in the north of Shropshire, and that an oblong tract is so coloured in all recent geological maps of England. A very concise account of the district is given in the great work referred to, but no other notice has been published regarding it. The occurrence of such a fossiliferous formation only forty miles from Liverpool is in itself an interesting fact, while the details deserve the attention of the Society.

Like many parts of the south of Cheshire, the north of Shropshire is very deeply covered with drift, composed of sand, gravel, and boulder clay. The country has an undulating surface, whether the rock beneath be Lias or Red Marl. The whole extent of the Lias is supposed to be represented by an area ten miles long by about four and a half in breadth, the greatest direction being N.E. by S.W., as indicated on the maps of the Geological Survey.

When Sir R. I. Murchison examined the country, thirty years ago, there seem to have been greater facilities

than now for seeing the strata exposed. There were then several borings being rigorously carried on in search of coal; in fact, it was that circumstance that led to his visiting the neighbourhood.

The Liassic strata were pierced at Heathgate, Moreton Wood, Prees Wood, Calvin Wood, Burley Dam, Marchamley, Cloverley, and Wolliston Common, all places indicated on the map of the district. The greatest depth would appear to have been reached at Wolliston, where, at four hundred feet, a little lignite was found, but nothing resembling a bed of coal.

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Near Burley Dam, at the north of the district, there is a brook section, a few yards west of Walk Mill. The strata are slaty, splitting into thin laminæ, which only contained a small bivalve shell, probably *Modiola minima*, but in considerable abundance. North of this locality is another brook section, where the Lower Lias again occurs under the word "very" of the sentence on the geological survey map, "very hard white and gray beds." The strata consist of hard, light coloured shales, but no fossils were discovered. If there be no unconformability between the Lias and the Red Marl, the passage beds of the two formations might be discovered in the brook which intersects the strata, but on the occasion of the author's visit there was no time to work out that interesting point. To the east of Burley Dam, about two miles from Brook's Mills, there is a very good section of the Red Marl; it consists of red, flaggy beds, with a few bluish spots and patches interspersed.

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elevation of 1,900 feet above the sea level. Mam Tor, or the shivering mountain, is composed of shales (the equivalents of the Yoredale rocks of Yorkshire) resting upon the Mountain Limestone. The lower beds are charged with bitumen, which has probably been derived from the denuded coal measures. The mineral was observed in the Blue John Cavern. The most remarkable feature of the Mountain Limestone is the occurrence of the singular caverns which impart to the rock so much of its interest. These were concluded to have been produced by the long continued percolation of water through what were originally narrow joints or fissures. An examination of the immense chasms known as Cave Dale and the Wynnats, leads to the conclusion that they were formerly caverns that have had the overlying rock denuded and their roofs removed.*

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REPORT OF THE FIELD MEETING AT WIGAN.

AUGUST 7TH, 1863.

This meeting was held under the guidance of Mr. William Bryham. The operation of sinking the new shaft at Douglas Bank Colliery was inspected, and then the Rose Bridge Collieries were visited, and the whole party, ladies included, descended into the workings. There are two shafts, one 600 yards deep direct to the Cannel and King coals, and another 300 yards to the Pemberton 4-feet mine, the latter communicating with the Cannel-mine by a second shaft, also 300 yards deep, worked by an engine under ground. After Mr. Bryham had explained the mode of working, the plan of the mine, and the mode of ventilation, in which he was assisted by Mr. Higson, the government inspector, Mr. Kearsley, and Mr. Bryham, Jun., the party returned safely to the surface. Meantime a number of the members of the Geological Society of Manchester had arrived, and the numerous company were invited by the proprietors, Messrs. Case and Morris, to luncheon in a large workroom, which had been fitted up and decorated for the purpose. Pleasing recollections of the day will be long cherished by those who were present.

ON THE IRONSTONE OF THE MIDDLE LIAS.

BY WILLIAM S. HORTON, F.G.S.

There is no district in England where the Lias formation can be studied to greater advantage than the Yorkshire coast, which presents a series of beds altogether attaining a thickness upwards of 800 feet. In the short limits of this paper it is proposed to give a merely passing reference to the upper and lower divisions, so as to refer more fully to the Middle or Marlstone band in the centre.

This formation has of late years assumed considerable importance as a source of iron, and, in the Cleveland district, North of Whitby, its discovery, or rather the practical attention it has received within the last dozen years, has resulted in an entirely new branch of industry and wealth to that part of the country. As a proof of this it is only necessary to instance the flourishing town of Middlesboro, with a population of 20,000, (for the most part dependent on the iron trade,) which, forty years ago, was represented by but one solitary farm-house; and, in like manner, all the villages in the neighbourhood of the iron work have vastly increased in size and importance. On the Yorkshire coast the Lias presents, in cliff sections, a series of beds upwards of 500 feet in thickness. About 300 feet of beds still lower are to be traced in the interior, giving a total thickness of above 800 feet to the Yorkshire Lias. In general terms the series is thus divided:—Upper Lias, shales, 200 feet; Middle Lias, 150 feet; and Lower Lias about 500 feet. It is in the upper part of the Marlstone of Middle Lias, immediately below the Upper Lias shale, that the ironstone beds occur. At Eston Nab, where the ironstone was first worked, the detailed section of the upper part of the Marlstone is as follows, in descending order:—Ironstone, 17 feet; shale, 7 feet; ironstone band, 1 foot 8 inches; again succeeded by shale. This thickness is, however, very exceptional, as this is the point at which the ironstone attains its greatest development, and the great thickness of ore is caused by the junction of two distinct seams, which in other places are separated by nearly eighty feet of shale. These seams are, at Grosmont, near Whitby, four feet each in thickness, and parted by thirty-one feet of shale, which, however, contains two other bands of ironstone, each about one foot in thickness, giving a total thickness of good ore at this place of ten feet. The upper of these seams is

designated the Pecten-seam, from the great number of *Pecten æquivalvis* found in it, and the lower the Avicula-seam, owing to a similar abundance of *Avicula cygnipes*. In every direction from Eston the seams grow thinner and thinner, especially to the S.W., where they may be said to die away altogether,—about Thirsk. The area of country over which these ironstone seams extend is estimated at about 200 square miles, capable of producing from 20,000 to nearly 100,000 tons of ore per acre. This ironstone is chiefly a carbonate of protoxide, of a greenish grey colour, yielding, according to the specimens analysed by Dr. Percy, at the Government School of Mines, 33 per cent. of metallic iron. These specimens were taken from the Upper or Pecten-seam; but, probably, the average yield would not be more than 30 per cent. The present total yield of Great Britain is in round numbers from three millions to four millions of tons of pig iron. Of this number the Cleveland district is producing about 700,000 tons, or nearly one-fifth of the entire amount. It will thus be seen that, although the Cleveland district has only been worked since 1848, it is entitled to be associated with the most productive iron districts in the kingdom. The lower half of the Marlstone series contains no workable ironstone, but is interesting on account of its varied series of fossils. As a contrast to the great development of these Yorkshire beds, I will now direct your attention to a section of the Lias at Fawler, near Charlbury, Oxfordshire. At this place, on the west side of the Oxford and Worcester Railway, the following details may be observed:—Upper Lias Clay, 6 feet; Marlstone, Upper division, Ironstone 10 feet; Lower division, Soft ferruginous sands, with nodules of iron ore, 15 feet, resting on the Lower Lias, the thickness of which is unknown, but, judging from analogy with the above formations, probably not very great.

It is interesting to observe that in this section, although quite insignificant when compared with the Yorkshire series, still the same divisions and main features are common to both. This ironstone, which, as it is found on the Blenheim estate, is known as the Blenheim ore, is thus identical in geological position with the Cleveland ore. Its mineral characteristics are also the same. The appearance of the rock at the surface is a bright red, and the springs which issue from it deposit a red sediment, but newly-raised blocks, which have not been exposed to the influence of the atmosphere, are of a deep olive green colour, and, under the lens, beautifully oolitic. Fossils are rather plentiful in some of the layers, but it is to be observed that wherever they occur in any quantity the quality of the ore is considerably deteriorated by the calcareous element thus introduced. The average quality of the ore is 32 per cent of metallic iron, thus being slightly better than that of the Cleveland ore. This advantage is, however, more than counterbalanced by the comparative nearness of the latter to the Newcastle coal field, as contrasted with the fact that the Blenheim ironstone has to be sent to the Staffordshire iron district to be smelted. This bed may be observed in several other localities in Oxon, more especially at Bradford, in the valley of the Windrush to the S.W., and in the valley of the Cherwell, to the N.E. of Charlbury, and at these places, although the ironstone is reduced in thickness to six feet, yet, as regards quality, there appears to be but little difference. The greater part of the area between the rivers Cherwell and Windrush is occupied by Oolite, and the parts of the outcrop of the Marlstone along the valleys of each river tend to prove that the ironstone forms one continuous stratum, extending underneath the Great Oolite. There is, therefore, good reason to suppose, taking into consideration the fact that the iron-bed is worked at

several places near Charlbury, that before many years elapse Oxfordshire will be numbered amongst the iron producing counties of Great Britain. Travelling west, the Marlstone gradually increases in thickness, but altogether loses its commercial value, till, at the well known section of Leckhampton, near Cheltenham, it attains a development of 115 feet.

DECEMBER, 1863.

The President, the Rev. Professor GRIFFITHS, in the Chair.

William Dawbarn and E. H. Birkenhead, F.G.S., were elected Ordinary Members.

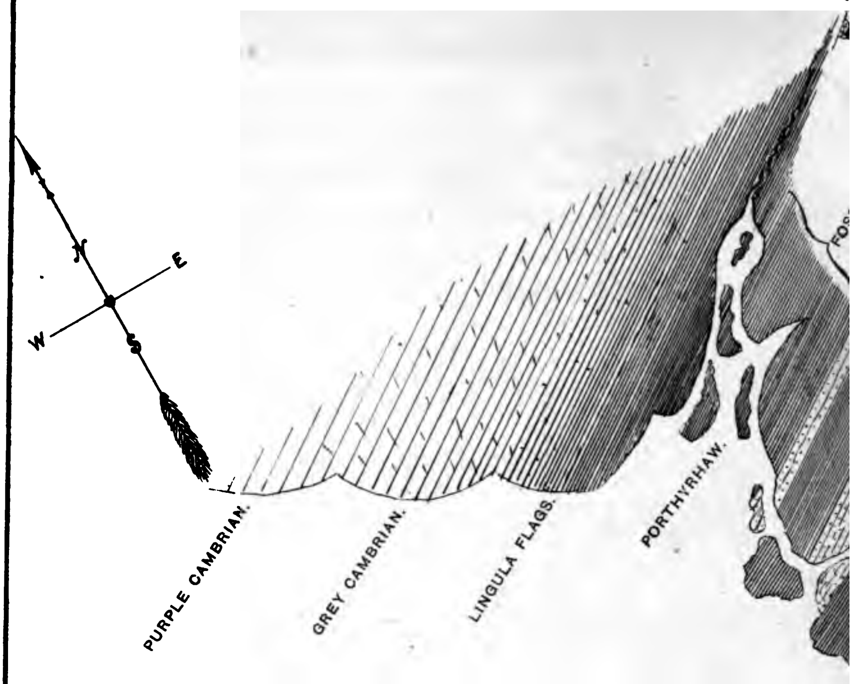
The following communications were read:

ON THE LOWER LINGULA FLAGS OF ST. DAVID'S, PEMBROKESHIRE.

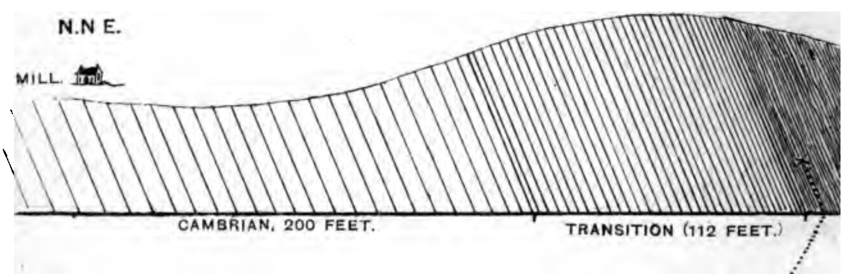
By Henry Hicks, M.R.C.S.E.

Having lately examined the fossiliferous beds of the Lower Lingula Flags in the neighbourhood of St. David's, Pembrokeshire, and with, I am happy to say, a certain amount of success, I thought it would not be unacceptable to the members of this Society to forward a few specimens of the fossils found there, for presentation to the Museum, and to accompany the same with a short analysis of the beds, as well as to give a few facts concerning their relative position, &c.

The presence of fossils in these beds was first made known through a paper in the Transactions of the Geological Society of London, for last February, by J. W.

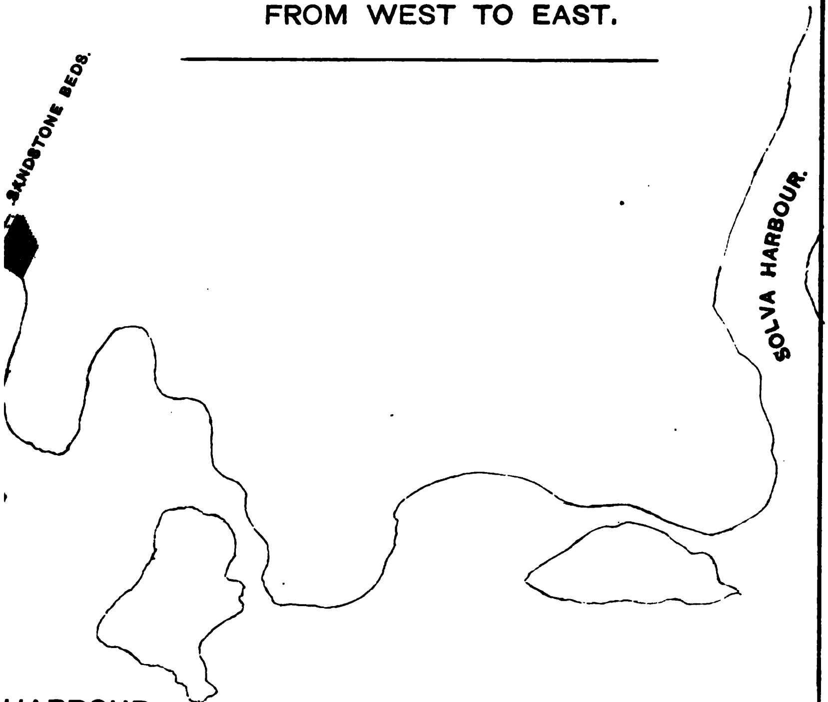


VERTICAL SECTION OF THE EAST SIDE OF PORTHYR
INCLUDING OVER 660 FEET OF STRA

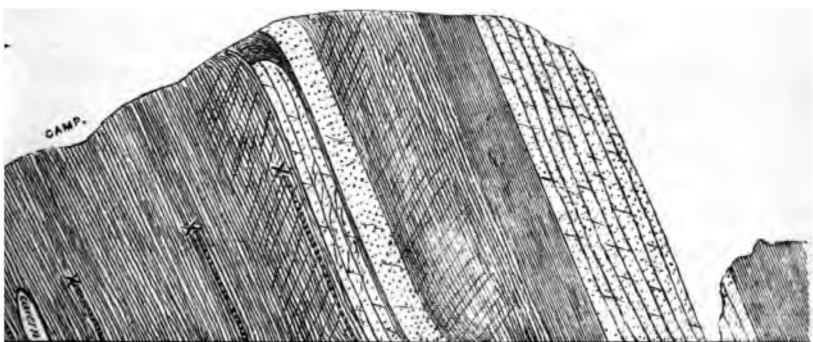


LINGULELLA.
OBOLELLA.
THECA.
AGNOSTUS.
MICRODISCUS.

HORIZONTAL SECTION
ACROSS PORTHYRHAW HARBOUR,
FROM WEST TO EAST.



HARBOUR,



LINGULELLA.	LINGULELLA. (RARE.)	THECA.
OBOLELLA.	OBOLELLA. (RARE)	AGNOSTUS.
THECA.	THECA.	PARADOXIDES.
AGNOSTUS.	AGNOSTUS.	
MICRODISCUS.	ANOPOLENUS.	
ANOPOLENUS.	SPONGE.	
PROTOSPONGIA.	*HOLOCEPHALINA.* (RARE.)	
HOLOCEPHALINA.	*CONOCORYPHE.*	
	PARADOXIDES.	

Salter, F.G.S., who there mentions his having accidentally come across them, whilst examining the Cambrian and Lower Silurian rocks of the above-mentioned neighbourhood in the summer previously, and of his having there found the gigantic Trilobite *Paradoxides*, of which he also gives a reduced drawing. Hitherto in Britain, although long sought for, this gigantic fossil of the Lower Silurian rocks had not been found in situ, and, indeed, but one poor specimen had ever been met with, which was in North Wales, some years before, although the locality from whence obtained is not yet known. I may further state that the two specimens are entirely distinct, the present being much larger, with a broader axis, and more like the *Paradoxides Bohemicus*, whilst the other is small and slender, and supposed by Mr. Salter to resemble the *Paradoxides Forchhammeri*.

The beds from whence these fossils were obtained are situated at Porth-y-Rhaw, a small creek on the north side of St. Bride's Bay, and about three miles to the E.S.E. of St. David's. They are also to be found on the west side of Solva Harbour, which is about a mile further to the east, although here they have been but little worked as yet.

In Porth-y-Rhaw, Lower Lingula Flags are found on both sides, but the principal fossiliferous beds are on the east side. A little to the west of the creek, as also just at its apex, (as seen in the horizontal section,) the Lingula Flags may be observed resting conformably upon and gradually merging into the grey Cambrian, the latter also, about a quarter of a mile further to the west, resting upon and merging into the purple Cambrians.

The purple Cambrian, or bottom rocks, are exposed to some extent along this coast, with a general dip from S.E. to S.S.E., and, although frequently disturbed by intrusive volcanic matter, yet show some fine sections of several thousand feet, and with an average height of from 150 to

200 feet from the sea level. These rocks are supposed to be continuous with those of North Wales, being similar in composition, as also entirely devoid of any traces of organic remains, and are, therefore, the true bottom rocks of both regions.

Reverting now to the horizontal section, which begins at the juncture of the purple with the grey Cambrian, to the west of Porth-y-Rhaw, and continued across that creek to Solva Harbour, we may, as already stated, observe the gradation upward from the grey Cambrian on the west side,—where it appears first, just above the mill, resting upon a mass of trap, and, consequently, both altered in structure, and thrown out of its usual course of stratification. for some little distance,—to the apex of the creek, where it is to be seen as a fine grained greenish grey sandstone, in beds of from three to four feet in thickness, thrown up to an angle of about 45 degrees, and with a dip from S.E. to S.S.E. From the last spot, upwards for about 100 feet, there is a gradual transition into the Lower Lingula Flags—at the lowest part, of course, resembling the underlying beds, and at the upper assuming a darker appearance, flag like, and becoming soon merged into the true Lower Lingula fossiliferous beds—the lowest of which, moreover, are light in colour and sandy, as compared with the upper beds of the series, where alone they obtain throughout a true black appearance. Succeeding these latter again we have thick beds of contemporaneous trap rock, then Lingula flags as unfossiliferous black schists, occasionally alternating with thick sandstone beds, and continued outward in one direction as far as the Cradle Rock, at which spot we probably meet with the highest beds that can be traced here, although at Whitesand Bay, to the west of St. David's, a section is to be seen in which the Lingula Flags rest conformably upon the Cambrian, and are succeeded in regular order by a lower member of the Llandilo formation.

This order of succession, moreover, is almost identical with that which occurs in North Wales, as observed by Professor Sedgwick and Mr. Salter. It may be tabulated in ascending order, thus:—

	Cambrian.	1. Coarse Conglomerates, in thick beds,
		2. Purple sandstone, ,, ,,
		3. Purple sandstone, with green bands.
		4. Greenish grey sandstone.
Lower Silurian.	Lower Lingula Flags.	1. Fine grained grey flag, at first slightly banded, or iron-stained, then gradually assuming a darker appearance, and at last changed into
		2. Black slates, in the upper part of which, and alternating with them, some thick sandstone beds are sometimes seen.
	Mid. & Upper Lingula Flags.	3. Thin alternating beds of sandstone and slates.
		Tremodoc slates.

Prior now to entering into a more minute analysis of these beds, as marked out on section 2, (which is a vertical one of the east side of the creek, cutting across the beds from N.N.E. to S.S.W.,) I may say that it will be impossible, in so short a paper as this must necessarily be, to give more than a bare statement of the facts as they occur here, without entering either into the theoretical discussion of the subject, or making comparisons with other beds of the same age, such as the Potsdam Sandstone of North America, the primordial Zone of Bohemia, or the Alum Schists of Sweden, &c., &c.

The beds here are undoubtedly (as already stated of the purple and grey Cambrian) continuous, or at least contemporaneous with the Lower Lingula Flags of North Wales, which also have yielded a few fossils, though not in an equal degree. It may also be worthy of observation that, although some resemble those found here, yet, as a rule, while they belong to the same great orders, each region has its species, or genera, differing from that of the other,—each has, as it were, its characteristic fossils,—proving, therefore, that in this short distance, at some remote period, some great causes must have been at work to produce so decided and marked results.

In the section, which includes from 600 to 700 feet of strata, it will be observed that I have marked the fossiliferous beds as having a thickness of about 214 feet, each separate bed also being more or less distinct, and about three feet wide, the lower ones being hard and sandy, with numerous joints, the upper ones slaty and much affected by cleavage, also containing frequently imbedded metallic nodules, and occasionally thin metallic and quartz veins running through, all probably in consequence of contiguity to the overlying volcanic beds. These beds are all nearly vertical in position, with a general dip to the S.E., and form magnificent cliffs, with strata of rippled rock frequently 150 feet high from the water's edge. Extending also along the cliff top, from the cavern direct to the extreme point, and resting immediately upon the fossiliferous beds, we may observe the remains of an old camp, (much of which, however, with the underlying beds, has been washed off from time to time,) which, though in *comparison* of but recent date, has its history hidden in as great obscurity as that of the *Paradoxides*, forming, therefore, with it a no unworthy association, but a combination equally deserving of a visit from the antiquarian *and the* geologist.

Returning again to the section, you will observe a x placed upon one of the lowest beds marked fossiliferous, this indicates the lowest bed in which I have as yet detected any distinct traces of organic remains; it is continued from the east side through the large blocks of rock in the middle of the harbour to the west side. Its contents were principally fragments of *Theca corrugata*, although possibly some of the smaller fossils found in the next succeeding beds may yet be traced there. All the beds from here upwards may be said to give some indications of remains, although certainly not equally so, the most prolific apparently being wide apart, and dividing the series as it were into about three stages, nearly equidistant the one

from the other. Adopting this method also in describing the position of the fossils, it will render it much easier and more intelligible. So that, beginning with the lowest marked, we may give that as containing only, according to present information, the *Theca*. [I have, however, found now that, although the *Theca* had certainly a very early existence here, it still was not unaccompanied, but had associated with it the little *Lingulella*, *Obolella*, *Agnostus*, and *Microdiscus*, (Fry ?) since specimens of each of these have lately been obtained from the lowest beds.—September, 1864.] Next we come to the sides of the *cavern*, where numerous small fossils are to be found, such as *Agnostus princeps*, *Theca corrugata*, *Lingulella*, *Obolella*, and the *Protospongia fenestrata*, also, more rarely, the *Anopolenus*, as also one or two other little fossils not yet named, but probably belonging to, or at least allied to, the *Olenus*. The Flag itself also at this spot needs observation, in consequence of its containing a larger proportion of lime than I have found at any other part of these beds, indeed so much so that a very decided effervescence is at once produced by dropping sulphuric acid upon it, or at least upon many parts of it.

The next marked beds are those in which the *Paradoxides Davidis* is found, as also the lowest in which we have as yet met with the *Conocoryphe*. These two species, therefore, it may be said, do not seem to have had an existence here until a fossiliferous deposit of about 150 feet had been formed; but, whether this may be looked upon as a natural or as an accidental circumstance, remains to be seen, since many further proofs will be necessary ere it can be decided. In these beds also we meet with nearly all the smaller fossils, but, as already stated, the *Lingulella* is much more rare here than in the lower ones. The lowest marked of the Paradoxides-beds is the one which has been chiefly worked, and the one from which all the best

specimens have been obtained; they are far more numerous here also than in any of the others, excepting, perhaps, the very uppermost of the series, where, however, they are much distorted by cleavage. These last beds are directly in contact with the under surface of the volcanic bed, and strangely, although the Lingula Flags are again found resting upon it, no trace of any fossils can be found higher up, although the most careful search has been made there for them. I may just mention also that the *Paradoxides*-beds are only found on the east side of the creek, in consequence (as you will at once observe by referring to the horizontal section) of the strike of the beds from the cavern upwards carrying them clear of the rocks on the opposite side, leaving only the very lowest ones, therefore, to be resting upon the Cambrian of the west side.

Having thus given a brief and hurried description of the section, it only remains for me now to name the specimens in the order in which they are numbered, and just to mention the several classes, &c., to which they belong. Before doing so, however, I must publicly acknowledge my great obligations to Mr. Salter, who has kindly, from time to time, named and classified the fossils as they were found by me, and to whom I am indebted for much other information concerning these beds. As already stated, it was he who first found and examined these beds, and by him was detected there the *Paradoxides Davidis*, as also the little *Agnostus* and *Microdiscus*, leaving the others to be subsequently discovered during our late examinations, which, I may say, have been carried on to some extent and with a proportionate amount of care, now and then, through the whole of the last six months.

The specimens are numbered in the order in which they are found, beginning with those that appear as yet to have the lowest position. This order, it may be, is not accurate, neither could I wish it to be received at present as though

it were so, since we know not what subsequent examinations may yet bring to light. Still it is that which has been repeatedly observed by us during our working of these beds, therefore I now place it before you as such. Moreover, is it not probable that this order, which gives a pre-existence to the smaller herbivorous feeders than of the larger carnivorous ones, should both show a design and a providence which never fails to become visible throughout nature's laws?

* Nos. 1 and 2, therefore, are specimens of the *Theca corrugata*, a Pteropod genus. It is, as already said, the lowest found, extends also through all the beds, and is one of the most prevalent.

Nos. 3, 4, and 5 are specimens of the little *Agnostus princeps*, a new species of the little Trilobite, found here very generally, and, like the former, extending through nearly the whole of the beds.

No. 6, *Microdiscus Punctatus*, occurring chiefly in the lower beds, is associated with the two former, as also with the next to be mentioned.

The *Lingulella*, Nos. 7, 8, and 9. These are, as far as I have seen, about their natural size, accordingly they are a much smaller species than the true *Lingula Davisii*, after which these flags are named. These specimens seem more or less pyritised, though some few are to be found of their natural tint. As yet they seem also to have been restricted almost entirely to the beds marked on the south of the cavern, where they may be said to be rather numerous, a specimen but rarely appearing in the Paradoxides-beds.

No. 10 is the *Protospongia fenestrata*, an entirely new type of sponge, rarely met with, and apparently restricted to the middle beds of the series.

Nos. 11 and 12 are fragments of the *Anopolenus Henrici*, a new genus of the Olenoid group, resembling somewhat

* The specimens are exhibited in the Museum of the Royal Institution.

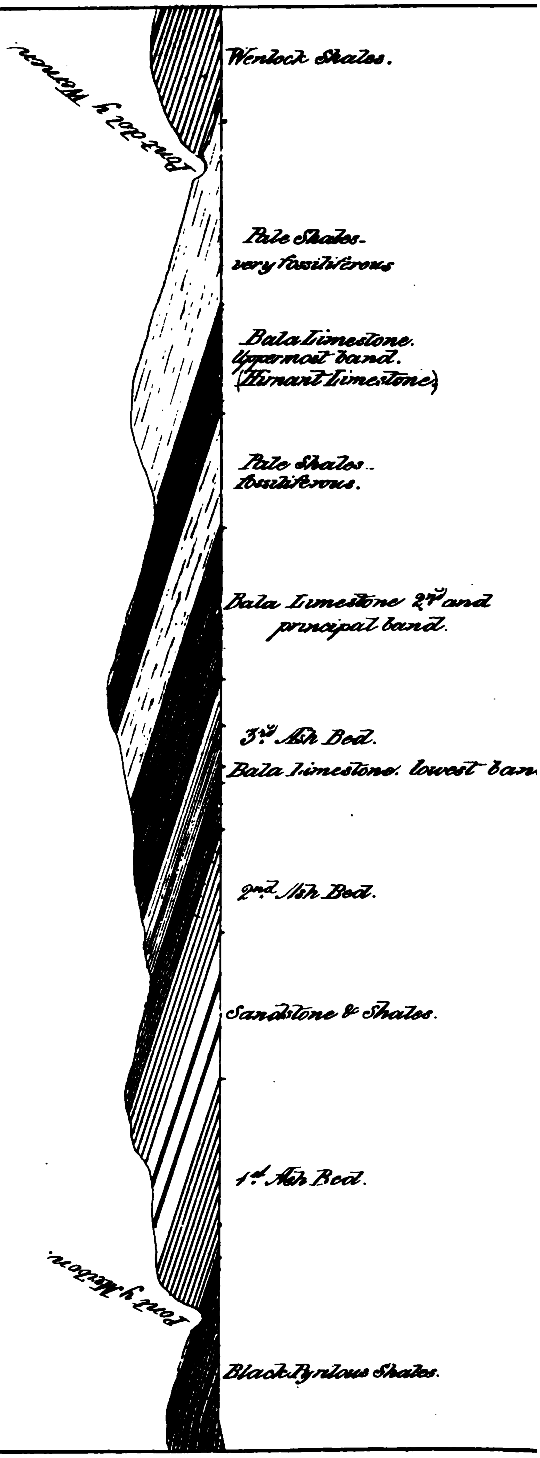
the American genus *Atops*, yet, however, entirely distinct. It is found here (though extremely scarce and rarely approaching a perfect specimen) in the middle beds of the series, that is, at the south of the cavern and in the first Paradoxides-beds. The fragments show the head and body segments, with portions of the pleuræ. The tail, which is multiserrated, and forming, in comparison, a very large segment, is so seldom found, that I was quite unable to obtain a specimen to send, although very anxious to do so.

No. 13 is the *Conocoryphe Variolaris*, a new and beautiful species. The head and body, though of two separate specimens, are to be seen on the same stone, both also belonging to ones of the largest size, and very perfect. This fossil is found only in the Paradoxides-beds, and chiefly in the lowest marked.

Nos. 14, 15, and 16 are parts of the great *Paradoxides Davidis*, each number representing some especial part, 14, however, being a nearly complete one, the upper part of the head only being absent, and is about the finest specimen obtained as yet. 15 represents the *head*, with a portion of the shield of a very large specimen, whilst 16 represents a moderately perfect and large *labrum*.

This species is probably the largest known in the genus Paradoxides, some specimens having (as shown by some fragments obtained) attained a truly enormous size for an inhabitant of the primordial Zone. It is found only in the upper seventy or eighty feet of the fossiliferous beds, no traces having been detected by me lower in the series. It is accompanied also by most of the smaller fossils, which probably at one time served to satisfy its cravings.

Those who have seen the figure of this fossil in Mr. Salter's paper in the Geological Transactions, will probably observe a material difference as existing about the *cauda* of the present specimen from that of the figure, hence it will be necessary for me just to state the cause, which arose



SECTION OF THE BALA LIMESTONE AND ITS ASSOCIATED BEDS, IN GLYN CEIRIOG, S. OF LLANGOLLEN.

in consequence of no fragments having been obtained at that time in which the *cauda*, with its pleuræ, were present, hence necessitating that part being filled up by conjecture. Mr. Salter, however, is now, I understand, preparing another corrected figure, in which these parts will be clearly defined, and it will appear in the next decade of the Geological Survey.

ON PERMIAN SYSTEM OF STRATA.

By George H. Morton, F.G.S.

ON THE CRYSTALLINE LIMESTONES OF DURHAM.

By George S. Worthy.

JANUARY 13th, 1864.

HENRY DUCKWORTH, F.G.S., F.L.S., Vice-President, in the Chair.

Henry Hicks, M.R.C.S.E., was elected an Honorary Member.

Thomas Gibson was elected an Ordinary Member.

The following communications were read:

ON THE BALA LIMESTONE AND ITS ASSOCIATED BEDS IN NORTH WALES.

By D. C. Davies, of Oswestry.

Among the finest views of the eastern portion of North Wales are those obtained from the summit of the Limestone ridges west and south of Oswestry. From any of these the spectator sees spread out before him a sea of hills,

rolling in graceful undulations towards the distant Berwyns, undulations diversified by perpendicular escarpments, rocky slopes, and conical peaks, among which wind deep ravines, that open out into charming valleys, reckoned among the most fertile in Wales. This district is classic ground to the geologist, rendered so, first and chiefly, by the labours of Professor Sedgwick, who was the first to unravel the intricate geology of North Wales, and, after him, by the labours of Murchison, and Salter, and Forbes, and the gentlemen connected with the Government Survey. The strata of which the district is formed are now generally known as Lower Silurian, or Lower Palæozoic, inasmuch as it contains the remains of very ancient organic life. It was originally described by Professor Sedgwick as "The Bala Group," and is now variously designated on maps as Bala or Caradoc, and Llandeilo or Bala, just as its upper or lower members appear to co-ordinate with those formations as they are elsewhere developed. Conspicuous in the geology of this district, both for the rugged beauty they, with their associated ash beds, give to the landscape, as well as for the abundance of their organic remains, stand the bands of Bala Limestone, with which the district is traversed. Adding to the result of the researches of former and more distinguished labourers, the result of my own, made during many, what were to me, at least, pleasant excursions, I propose in this paper to give a short and as clear and intelligible an account as I can of the "Bala Limestone and its Associated Beds."

From the lake and town of Bala (whence it derives its name) the Bala Limestone stretches south towards Dolgelly, and loses its distinctive characters as it approaches the coast line of South Wales. Some of its features may, however, be recognised in the great cutting of Talerddig, on the Machynlleth Railway. Northwards, it extends along the eastern side of the valley of the Dee, towards

Llandrillo. The portion, stretching north and south of Bala, dips under the Berwyn range of mountains, and rises again on their eastern side, forming a longitudinal trough, in which the great masses of Tarannon and Wenlock shales and Denbigh grits, of which those hills are composed, are deposited. This eastern outcrop of the Bala Limestone extends from Llandrillo eastward, flanking a branch of the Berwyn hills, until it terminates in the valley of the Ceiriog, south of Llangollen, and southward by Pennant and Hirnant, to a point south of Llanwddyn; it then bends sharply round to the east, forming the remarkable ridges of Das Eithen and Penygarnedd to Llechwyd Llwyd, (where it terminates on the Government maps.) From hence it extends, in broken lines, north of Llanfyllin to Penypark and Alltygader, to the hills south east of Meifod and the country lying about Welshpool and Guilsfield, and then back along the valley of the Vyrnyw, forming the ridges of Bwlch-y-Ciban and Brongwain, towards Llansaintfraid. I may also say that, from various specimens shown to me from Llanyblodwel, from the development of its accompanying ash-beds between Llansiln, Llangedwin, and Llanrhaidar, from its characteristic fossils, obtained by myself and others, I am led to believe that it exists in numerous detached portions throughout the district lying between the Berwyn hills and the Mountain Limestone of the Welsh border. Similar fragmentary portions of this Limestone are found on the north west of Bala, and extend thence towards the district west of Corwen, and westward towards Bettws-y-Coed, capping the summit of Snowdon, and contributing, with its ever-present trappean ash, to the rugged scenery near to Penmaenmawr and the Pass of Aber.

The beds more particularly referred to in this paper rest upon a great zone of dark earthy and often pyritous shales and slates, which occupy an intermediate position

between them and the Ffestiniog slates, and which may be considered as well developed in the vicinity of Llangadwalader, west of Oswestry. Starting from this point, and proceeding westward or northward, in which directions the Bala beds attain their maximum development, we should traverse, in ascending order, (geologically speaking,) first, the said zone of earthy slates, second, a series of altered grits and shales, interstratified with two principal layers of Felspathic ash, more particularly described in my paper on the geology of Glyn Ceiriog. Above the second, we arrive at a thin band of impure limestone, another felspathic band, next, the principal band of Bala Limestone, attaining a thickness of about 300 feet; above this, a series of shaly beds, very fossiliferous, and this in its turn overlaid in places, as in the valley of the Hirnant, near Bala, and seen to more advantage in Glyn Ceiriog, with a third band of limestone, sometimes termed the "Hirnant Limestone." From Glyn Ceiriog westward, towards Corwen, and eastward, until it is cut off by the Carboniferous Limestone, near Selattyn, this third band is capped by a pale shale, abounding with fossils, and then the whole series dip (for the most part unconformably) under beds belonging to the Wenlock, Ludlow, and Carboniferous groups.

These beds everywhere occupy a highly-inclined position, so much so that in the Vale of Meifod, and near to Llanfyllin, the strata are quite perpendicular, and the fossiliferous layers form an upright wall on either side of the grotesque quarries; while at Das Eithen ridge, near Llanrhaidar, the whole series is thrown completely over, and presents the anomalous appearance of the older beds resting upon the most recent. When we remember that the whole group must have originally been deposited on a nearly horizontal plane, we may form some idea of the powerful and widely-spread throes of nature, by means of

which it was, after its deposition, perched at such high angles, and thrown into its present subverted condition. Those of you who are acquainted with the valley of the Ceiriog, above Llansaintfraid, or that of the Hirnant, near Bala, or have seen the romantic waterfall of Pont-y-Glyn, near Corwen, or are at all generally familiar with the district referred to, will perceive that it is to this up-throw of the strata, with its attendant transverse fissures, together with the alternation of hard limestone and ash beds with softer shale, that North Wales is indebted for some of its most ruggedly picturesque scenery.

The dark earthy slates and shales forming the base of this group have not afforded many fossils in North Wales, and, with the exception of a few forms of Graptolites, and obscure crustaceans, their equivalents elsewhere, as in the Moffat group, and along the shores of Cardigan Bay, seem to partake of the desolation attendant on the absence of organic life. This absence of fossils continues until we have passed the second band of felspathic ash, and then, in a thin and but little known bed of impure limestone, we all at once meet with the remains of a platform of rich and varied existence. Just as in mountainous districts the traveller, who has long wended his solitary way along lonely glens and mountain moorland, is suddenly brought by a bend of the road to town or village, full of life and activity, so the geological explorer, after a long traverse of the lower strata, containing but few tokens of former life, joyfully hails the abundance of fossils he finds in this lowest band of limestone as the memorials of the time when a hitherto all but lifeless sea teemed with myriads of animated things. This band may be studied near some old mines at Hafod-y-Garreg, in the glen of the Deirw, south of Llangollen, and it is possible that the rocks of Garnedd, west of Bala Lake, may be its equivalent. Conspicuous among the fossils of this lowest band rank the

Brachiopoda, represented by the genera Lingula, Leptæna, and Orthis; of the latter O. Elegantula is the most abundant, and is remarkable as ranging in time through all the higher strata up to the Wenlock group. The Lamellibranchiate shells are represented by the Modiolopsis; and the Stenopora Fibrosa, and the everywhere present Petraia (Turbinolopsis) herald the approach of the Corals; stray plates, delicately sculptured, betoken the existence of Echinoderms. It was from a bed of this age, on the west of Bala Lake, that the beautiful Protaster Sedgwickii was obtained. The most abundant Crustaceans are Phacops and Asaphus. These forms are but sparsely sprinkled throughout the finer portions of the overlying ash beds, and disappear altogether from the coarser layers, but, as soon as the sediment assumes a calcareous nature, reappear, for the most part in the second and principal band of Bala Limestone, and have their numbers increased by the addition of many new genera and species. Thus to the Crustaceans are added Calymene, Homalonotus, and Trinucleus. Among the Brachiopoda we observe a number of the larger Strophomena and Orthis, as S depressa, O Flabellulum, O Grandis, and O Actoniæ freely mingling with the older forms; Echinosphærites is conspicuous among the Echinoderms. The Corals increase in number and variety as we ascend towards its upper portion, and the Univalve shells, Cephalopoda and Gasteropoda, which were scarcely represented in the lower band, appear in great abundance. This band of Limestone is characterised by several ferruginous layers of fossils, which vary from six inches to a foot in thickness, and follow the whole course of the Limestone, and appear wherever it is developed in North Wales. In the centre portion of these layers the fossils are often much decomposed, but appear in a more perfect form as the solid limestone is reached on either side. There is also often in them a considerable admixture of sand, and this probably

has led the Government Surveyors into the error of mapping the country north of Llanfyllin as "Fossiliferous Sandstones," whereas it seems to be composed of an alternation of ash and shale and Bala Limestone, interleaved in the usual way with the thin layers referred to. In these layers the fossils are often a good deal broken, and present a curious admixture of the corresponding valves of various genera and species, such as is often observed on existing sea beaches, and in places (at Bwlchy Ciban for example) there is a considerable breadth of the upper surface covered with thin laminæ of sediment, following each other in wavelet undulations such as are now peculiar to muddy shores, and still further exhibiting the cracks made by the sun's heat when the receding tide had left the shore dry. Hence, I think we may fairly infer that these layers represent a space between the laminarian zone and high water mark, and, considering their breadth and continuous thickness, it would seem that, however highly inclined the strata may now be, they were originally deposited in a horizontal position, and that these fossiliferous layers were so many muddy flats, bounding an ancient sea.

The fossils are usually well preserved in the compact limestone, and here their habits and grouping may be best studied. The fossils abundant in this principal band of limestone are continued through the overlying shale to the uppermost bed. Corals, however, become much more abundant, and the beautiful creatures belonging to the Bryozoa appear in great variety. Among the Crustaceans, Illaenus is more frequently met with. The remains of life continue to increase in diversity as the uppermost shales are reached, and then (in North Wales) disappear as we approach the deep sea deposits represented by the Wenlock shale.

There have been described from these beds in North Wales, of Radiata, (corals,) about 28 species; of Echino-

dermata, (star fishes, &c.,) about 10 species; of Crustacea, (allied to the crab fish, &c.,) about 30 species; of Mollusca, (shell fish,) about 92 species, divided thus—Brachiopoda, (equal sided shells,) 57; Lamellibranchiata, (as mussels, &c.,) 10; Pteropoda, (wing footed,) 1; Gasteropoda, like snails, &c.,) 12; Cephalopoda, (like cuttle fish, &c.,) 12—92. This, though by no means a complete list of the fossils of the Bala rocks of North Wales, will afford some idea of the nature and variety of the forms of life prevalent in those early seas.

Many attempts at mining have been made in the ash beds and limestone, but beyond a few veins of pyrites and what our Welsh neighbours call "eyes of lead" there has not any mineral been found in these beds to repay the miner. Efforts made in the dark, unfossiliferous strata below have been more successful, especially when made in the vicinity of eruptive rocks. In the ash beds the pyrites often assume the shape of large separate cubes, having the angles cut off, and presenting the facets of 16 or 18 symmetrical sides. Some good examples of these may be obtained from the ash bed underlying the fossiliferous shale at the Moelydd. At Pont-y-Glyn, west of Corwen, the pyrites form themselves into round balls, from each hemisphere of which a cone of horny substance projects for one or one and a half inches, and frequently we find several such forms in a cluster. It may be that this appearance may have some affinity with the curious cone-in-cone structure which is also common in the Bala rocks. I cannot better illustrate this curious form than by comparing it to a space covered with funnels as closely as they can be placed, and piled up one on the other to an indefinite height. The prevailing form of crystallization in the solid beds is rhomboidal, and may be observed equally in the structure of the rock masses and also in the breaking up of the fossiliferous layers referred to, where the lines of fracture often provokingly cut most coveted specimens into fragments.

The Bala group is represented in the north of England by the Coniston Limestone and its associated beds. In South Shropshire its upper portion is imperfectly represented by the Caradoc Sandstone and shales, of which a typical section may be observed along the banks of the Onny. The Llandeilo flags and shale of South Wales may be regarded as the equivalent of its lower portion. These two formations, by a beautiful succession of conformable strata, and by an identity of fossils, are in North Wales linked into one.

The portion of the Bala group we have been considering, amounting, as it does, to a thickness of from two to three thousand feet, must represent a vast cycle of time, while the very different lithological texture of some of its members, varying as it does from fine grained lime and sandstone, through shaly and rather bituminous layers, to the coarse breccia of the ash beds, suggests to us an infinite variety of subaqueous conditions. Here, if anywhere, we might expect to find illustrations of the theory of the "Evolution of species by the gradual alteration of existing forms." I do not think, however, that the evidence yielded by these deposits is, on the whole, favourable to that theory, for if I read it aright it is something like this: In the lowest beds we find a certain number of species of various orders, Radiata, Echinodermata, Crustacea, and Mollusca. Each species seems to have its central typical form, with varieties diverging on either side until they approach the like divergent varieties of other species. Thus, on an horizontal line representing SPACE we have species with central forms, very distinct, but united by divergent varieties; and then ascending upwards through strata representing TIME we meet with the same central types and the like variations surviving through an immense period of time, and all the many changes of condition referred to. New species are added in the upper beds, but we do not meet with that gradual VERTICAL divergence from the old types to the new which

would certainly be the case if such new species were but the modified descendants of the older forms. And if we contrast the species which appear for the first time in the middle or upper bands of Limestone with those characteristic of the old, suppose we take Orthis and Leptæna among the Brachiopoda, or corals among the Zoophytes, we shall perceive how great the divergence is, and we look in vain for those transitional forms which, supposing the theory to be true, we ought certainly to find in the intervening strata. The accompanying section, kindly drawn by Mr. Whitwell, of Oswestry, describes the series as it is developed in Glyn Ceiriog, and may be regarded as typical of the formation as it is exhibited in North Wales. I hope before long to append a list of the fossils hitherto found in these beds in North Wales.

ON THE GEOLOGY OF LINCOLNSHIRE.

BY WILLIAM S. HORTON, F.G.S.

FEBRUARY 9TH, 1864.

THE PRESIDENT,

THE REV. PROFESSOR GRIFFITHS, IN THE CHAIR.

The following communications were read:

ON THE SAN CIRO CAVE, NEAR PALERMO.

BY HENRY DUCKWORTH, F.G.S., F.L.S.

(ABSTRACT.)

In the course of my travels in the Mediterranean, last year, I visited Palermo, the beautiful capital of Sicily, and although my stay there was necessarily brief, I was

unwilling to leave without seeing some of the bone caverns in the vicinity of the city. The Grotta di San Ciro was the only one I was able to visit, and I trust that the following description of that celebrated ossiferous cave may not be without interest.

The Plain of Palermo, or "Concha d'Oro" as it is termed, on account of its extreme fertility and beauty, is enclosed within an amphitheatre of hills, varying in height from 1,200 to 3,000 feet. These mountains are principally composed of Hippurite Limestone, (a cretaceous formation, and so called after its most characteristic fossil,) and their bases are more or less studded with ossiferous caverns.

The most important of these caves is the Grotta di San Ciro, which is situated on the east side of the bay and at the foot of the Monte Griffone. The present dimensions of the cave are—length, about 130 feet; height, 50 feet; breadth, 30 feet. Its contents having been almost entirely removed, we are compelled to rely upon the accounts of the Abbé Scina, Christie, Hoffmann, and Dr. Falconer, for a description of its former condition. At the mouth of the cave, however, is a series of deposits which appear to be similar to those which originally filled the interior; these consist of—

First band, containing marine shells of recent type.

Second band, a mass of breccia, about twenty feet in depth, and composed of limestone, quartz, and brown earth, together with the bones of two species of Hippopotamus, Elephas antiquus, Bos, Cervus, Ursus, and a large feline animal.

Third band, another mass of breccia, very similar in character to No. 2, but less coherent.

Fourth band, a layer of large and loose fragments of limestone, locally termed "*Lastroni,*" about six feet thick.

Fifth band, a bed of ochreous earth, about one foot in thickness.

The only organic remains I succeeded in discovering were teeth (principally molars) and fragments of bones of hippopotamus. The remains of this animal seem to have always been greatly in excess of those of the mammals before mentioned. I noticed that the walls of the cavern were abundantly perforated by pholad borings, clearly proving that the sea must at one time have entered the cavern.

* * * * *

The hippopotamus, as need hardly be observed, has long been extinct in Europe, and is now exclusively confined to the African continent; the conditions under which it existed in Sicily must therefore have been widely different to those which obtain there at present.

There can be no doubt that during the Pliocene period, at any rate, Sicily formed part of the African mainland, and vast Nile-like rivers, abounding in hippopotami, flowed northwards through its wide and fertile plains into the Mediterranean. In further proof of this theory, I may mention that the molars of the living African elephant have been discovered in the grotto of Olivella, near Mondello, in the neighbourhood of Palermo.

The distance between Marsala and Cape Bon, the nearest respective parts of Sicily and the African coast, does not amount to more than eighty miles, and Admiral Smyth, in his learned work on the Mediterranean Sea, states that there is a subaqueous plateau (named by him Adventure Bank) uniting Sicily to Africa by a succession of ridges, which have not more than forty to fifty fathoms over them. Malta, Gozo, and the adjacent islands, must have also been incorporated during the same period with the African mainland, and it is interesting to know that caverns have been discovered in the first mentioned island containing a breccia

very similar in appearance to the Sicilian one, and abounding also in hippopotamus remains.

*   *   *   *   *

I take it that at the dawn of the Newer Pliocene period the northern coast of Sicily was suddenly submerged, and the sea, as it flowed in upon the land, carried before it the loose soils of the plains and their imbedded organic remains, depositing them at the base of the Hippurite Limestone rocks. The further course of the heterogeneous mass was, of course, impeded by this barrier, and, naturally accumulating there, every cavern, crevice, and sheltered nook was filled up with the ossiferous breccia, the calcareous nature of which caused it to indurate rapidly. The *hard* beaches of Sicily are at the present day one of its characteristic physical features. Admiral Smyth states that the shore between Messina and Scaletta is generally hardened into a compact conglomerate, of which small millstones are made on the spot. In due course an upward movement of the land took place, and the sea margin appears to have maintained its level for a lengthened period some thirty to fifty feet below the mouths of the caverns. No doubt during this period much of the ossiferous breccia was swept away, and it was only what remained inside and at the entrances of the caves that escaped.

ON THE PRECIOUS STONES.

BY FREDERICK P. MARRAT.

MARCH 8TH, 1864.

FREDERICK P. MARRAT, Esq., in the Chair.

The following communications were read:

ON A SECTION OF THE STRATA AT THATTO HEATH, NEAR RAINHILL.

By George H. Morton, F.G.S.

The object of this communication was to show the certainty of productive beds of coal being beneath the Trias, and that they were cut off by the great fault which throws up the coal measures.

ON THE FOSSILS IN THE COLLECTION OF THE DERBY MUSEUM OF LIVERPOOL.

By Thomas J. Moore, Corr. Memb. Z.S.L.

Of this paper the following is a summary:
The collection, though small compared with the zoological portion of the museum, has many specimens of interest. It originated in an extensive purchase of fossils from Mr. Edward Charlesworth, F.G.S., well known for his attention to the crag formation of Norfolk and Suffolk. The fossils from the crag and other Tertiary beds are both fine and numerous.

Among the specimens purchased from Mr. Charlesworth were many which formerly belonged to the late Dr. Mantell, including a fine series of vertebræ and limb bones of the Iguanodon, and some very fine Cephalopoda, from the Oxford clay of Christian Malford.

About the same period valuable donations of remains of Elephas, &c., from the Sivalik Hills, were received from

Colonel Sir P. Cautley; and a series of casts from the unique specimens, from the same region, in the British and East India Museums, were received from the late East India company.

To this nucleus additions have from time to time been made, among which may be mentioned the following:

A fine series of skulls and horns of *Bos primigenius*, a perfect skull of *Bos longifrons*, horns of *Cervus*, &c., from the bed of Wallasey Pool.

A series of Lower Silurian fossils, from the neighbourhood of Shelve, collected by the curator, in company with Mr. Morton.

A fine specimen of *Pterygotus acuminatus*. from the Upper Ludlow Rocks.

A fine series of Devonian Corals, named and presented by Mr. Pengelly.

Some very good Carboniferous Limestone fossils from the north of Ireland, presented by Sir Thomas Deane.

The cranial bones and scutes of *Trematosaurus Brauni*, from the Trias of Germany.

The skull and many of the bones of the great cave bear, *Ursus spelæus*, from Arriege, France.

Cave remains from Malta and Sicily, presented by Mr. Duckworth and Dr. Adams, also a few from Cefn Cave.

The skeleton of *Megaceros* and bones of various species of *Dinornis*, from the Derby collection, and some very fine leg bones and vertebræ of *Dinornis giganteus*, presented by Sherbrooke Walker, Esq.

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WRIGHT, B. M., Great Russel-street, London.

*Read Papers before the Society.

ABSTRACT

OF THE

PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY,

SESSION THE SIXTH,

1864–65.

LIVERPOOL:

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OFFICERS, 1865.

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CHARLES RICKETTS, M.D.

ABSTRACT OF THE PROCEEDINGS

OF THE

Liverpool Geological Society.

SESSION SIXTH.

OCTOBER 11TH, 1864.

GEORGE S. WORTHY, Esq., in the Chair.

Mr. C. S. GREGSON exhibited the perfect antlers of Cervus Elaphus, from the old land surface, projecting from under the sand-hills at the mouth of the River Alt, near Formby.

The following communications were read:

REPORT OF THE SOCIETY'S FIELD MEETING AT LLANGOLLEN, JULY, 1864.

BY G. H. MORTON, F.G.S.

The meeting was arranged to meet the Manchester Geological Society, and the Dudley and Midland Geological Society and Field Club. Although the examination of the geological features of the neighbourhood formed the principal attraction, a party of botanists, under the guidance of Mrs. Bickerstaffe, of Llangollen, proceeded to collect the flowering and other plants of the district.

The geological party, under the direction of Mr. G. H. Morton, F.G.S., proceeded to the Flagstone Quarries, about four miles distant, where the Wenlock shale is exposed, and extensively worked for various economical purposes. Many good specimens of *Orthoceras primævum* and *Cardiola interrupta* were obtained, those being the only fossils that occur there, excepting a few very rare species.

The magnificent cliffs of Mountain Limestone known as the Eglwysegle Rocks were also visited. The locality is very interesting, on account of there being beds of red marl cropping out from under the base of the limestone, and supposed to represent the Old Red Sandstone. Many fossils of the usual Carboniferous species were obtained, including *Productus Llangollensis.*

The second day was devoted to the examination of the Bala beds of Llansaintfraid and Glyn Ceiriog. The Bala formation there consists of shales, interstratified with three distinct bands of limestone, and the same number of volcanic ash beds. Mr. D. C. Davies, of Oswestry, conducted the party, and many fossils were obtained.

A complete list of the fossils of the Bala formation, by Mr. Davies, is published in the present Abstract of Proceedings.

REPORT OF THE SOCIETY'S FIELD MEETING, AT BIDSTON HILL, August 27th, 1864.

By G. H. Morton, F.G.S.

The chief object of interest was the base of the Keuper formation, which is there very well exposed, and consists of a coarse conglomerate. Beneath it is the Bunter Sand-

stone, and Mr. Morton pointed out the very strong appearance of unconformity between the two formations. He referred to the instance described by Mr. Hull, F.G.S., as occurring near Ormskirk, in Lancashire, and having carefully examined that section, was of opinion that the one at Flaybrick (close to Bidston) is in every respect as conclusive, though not so completely exposed. The same general description applies to both localities, for in each section there are false bedded and soft Bunter Sandstones, without any very distinct dip, with a flat eroded surface, covered by the conglomerate of the Keuper.

The site of the glacial markings, discovered at the same place, by Mr. Morton, was shown, but the rock is now almost covered up; and after some time had been spent in the quarries, the proceedings terminated with tea at the village inn.

ON THE RECORDS OF GEOLOGICAL TIME.

By G. H. Morton, F.G.S.

The author reviewed some very important conclusions regarding the earth's history. He referred to the many instances of unconformity throughout the stratified series of geological formations, and considered them to prove, that no country presented a perfect and continuous series of deposits. That in every quarter of the world there are formations representing successive, though isolated, periods of time, that seldom, if ever, exactly co-ordinate; and consequently, the strata in one country may often represent the "breaks" in the succession of another; so that it is only by an examination of wide regions of the earth's surface that we can hope to obtain a tolerably correct history of geological progress.

NOVEMBER 8TH, 1864.

THE PRESIDENT, HENRY DUCKWORTH, ESQ., F.G.S., F.L.S., F.R.G.S., in the Chair.

CHARLES POTTER and JAMES WASON were elected Ordinary Members.

The PRESIDENT delivered his opening address.

He reviewed the proceedings of the Society during the last session, and referred at length to the most important communications that had been printed in the Report of the Society's progress. In a general review of the present state of geological science, he alluded to the origin of granite, and, more particularly, to the "breaks" in series of stratified rocks, both of which are subjects of great interest at the present time.

The following communication was then read:

ON THE SECTION ALONG THE COURSE OF THE AVON, AT CLIFTON.

BY G. S. WORTHY.

DECEMBER 13TH, 1864.

THE PRESIDENT, HENRY DUCKWORTH, ESQ., F.G.S., F.L.S., F.R.G.S., in the Chair.

JOHN BAKER EDWARDS, Ph.D., F.C.S., was elected an Ordinary Member.

Mr. R. BOSTOCK exhibited a section showing the juncture of the Millstone Grit and Trias in Flintshire.

The following communications were then read:

SOME CONJECTURAL HINTS TOWARDS DETERMINING THE ANCIENT COAST LINE OF NORTH WALES, BETWEEN THE RIVER DEE AND THE ISLAND OF ANGLESEA.

By Charlton R. Hall.

There are very ancient traditions, preserved in MS. and current amongst the Welsh, of the submergence by the sea of more than one portion of the coast of North Wales, and there are certain remains and facts which appear to confirm these traditions, and to lead to the conviction that at some remote period inundations of the sea have occurred, which have much altered the configuration of the coast, and changed the course of rivers at their mouths, and suddenly swept away the inhabitants and their habitations of large tracts of country. One such tradition there is, as I am informed in a communication from my friend, the Rev. Richard Parry, of Llandudno, of the inundation by the sea of Cantre'r Gwaelod, or Lowland Hundred, in Merionethshire. He writes:—"The substance of the tradition is as follows: At the ebb of the tide part of a long stone wall, which runs out into the sea from Mochras, a point of land a few miles south of Harlech, may be seen. It is called Sarn Badrig, or St. Patrick's Causeway, an astonishing work, being throughout twenty-four feet thick. It runs out to sea in a serpentine manner about twenty-two miles from the coast of Merionethshire, about half-way between Harlech and Barmouth. The principal city in the locality is supposed to have been *Caer Wyddno*, or Gwyddno's city. This Gwyddno was the last of its princes, and flourished from about the year A.D. 460 to 520; he was surnamed *Garan-hir*, or the long-shanked. At the end of Sarn Badrig are sixteen large stones, one of which is four yards in diameter. *Sarn-y-Bwlch* runs from a point north-west of Harlech, and is supposed to meet at the end of this. It appears at low water, near the mouth of the Dysynni. The space between

these formed, several centuries ago, a habitable hundred of Merionethshire, called *Centre'r Gwaelod.* These walls were built to keep out the sea. Sarn signifies a causeway or pavement. These ridges of huge stones are supposed by some to be the work of art, while others think them to be skeletons of hills reduced to their present state by the repeated action of the tides. The oracles of the cloister have said they are a footpath miraculously formed by St. Patrick to expedite his passage to and from Ireland. That this part of the sea was formerly dry land seems to be well attested by immemorial tradition. The catastrophe of its being deluged is also recorded in ancient verse, preserved in very old MS., called the Black Book of Caermarthen. The inundation is said to have happened about the year 500, owing to the negligence of a drunkard of the name of Seithenin, who left the sluices of the embankment open. The baron of the manor was Gwyddno Garanhir, father of Elphin, patron of Taliesin, the chief bard." It is no part of my purpose to consider this tradition, but I have introduced it to your notice in the words in which it has been given to me, partly to put it on record, and partly in the hope that some inquirer may study that part of the Welsh coast, with a view to determine the amount of truth which may be buried in these treasured memories of the Ancient Britons. Sarn Badrig is marked upon Black's travelling map of North Wales.

I have been familiar for many years with a tradition of an inundation of low-lying land in the immediate neighbourhood of the Great Ormeshead. The original inhabitants of the locality, before English residents were common amongst them, used to repeat the tradition with an undoubting confidence that such an event did occur at some remote period. An intelligent visitor of the locality can hardly fail to notice signs which tend to render probable the truth of the tradition. It is an undoubted

fact, to which I can, from long observation, testify, that the sea is encroaching upon the Great Ormeshead, and is rapidly crumbling down the south-western slope of the mountain, that is the side washed by the bay into which the Conway river now flows. The north and north-eastern sides present the solid rock to the ever-beating waves, yet even here the never-ending action of the water tells upon the masonry of nature, and from time to time dislodges from their primal bed large blocks of stone, and, as seen here and there, in the confused heaps into which they have fallen, we read the evidence of that unvarying law of change from which even the everlasting hills are not exempt.

I may notice here that there are two remains of art upon the Great Ormeshead which bear witness that great changes have occurred, and that the land has been displaced by the water. Upon the eastern edge of the mountain, close upon the sea, upon a rapidly descending slope, there stands the old church of St. Tudno, which, a few years ago, was a ruin, but it is now restored, for the use of visitors to Llandudno during the Summer season. The position of that church is such as at once to indicate that it could not have been built for the use of the population, as that population was located before the fashionable watering-place of Llandudno was built. In fact, it was about as remote from the dwellings of the people as it could possibly be. It is difficult to account for its being placed where it is unless upon the supposition that the slope of the mountain on which it is built stretched out seaward into a plain, upon which were the farms and dwellings of the people, and which have all long since been swept away.* Upon the exactly opposite or western side

* There is also on the same side of the mountain, just beyond where the new lighthouse is built, at the bottom of a gorge called the Llech, a cave, which, when I first became acquainted with Llandudno, was accessible to adventurous climbers by a dangerous declivity. I once made the descent, and returned the same way. It can now be visited only

of the mountain, upon its edge, or rather upon the extreme edge of what remains of the plain, which has evidently stretched out into what is now the bed of the Conway Bay, there stand fragments of the ruins of Gogarth Abbey. Portions of the remaining walls overhang the beach, testifying most unmistakably that the land extended far over what is now washed by the sea. This side of the mountain, consisting of loose earth, filled with stones, from pebbles to immense boulders, is being rapidly disintegrated by the tides, and, within the period of my own observation, considerable margins upon which I have seen the husbandman expending his industry have been crumbled down, and every winter is circumscribing the narrow slip of cultivable land, and consigning it to the domain of the ever-grasping sea.

Now it is the plain, of which this fragment remains, and upon which the ruin of Gogarth Abbey stands, that is the chief subject of this paper. If the conjectures here submitted are well founded, this valley, now submerged, may be described as having extended from the eastern edge of the Island of Anglesea to a point considerably above Conway, and beyond the embankment and tubes which form that portion of the Holyhead Railway. It lay between the Great Ormeshead on the one hand, and the range of mountains which stretch from Conway to Bangor

by means of a boat. At that time it was called St. Tudno's Cave, and was said to have been frequented by the patron saint of the locality, St. Tudno, from whom Llandudno derives its name, and who used to retire to this solitary cave to offer prayers for mariners. It was architecturally decorated with stone pillars, and there was a stone basin and a seat.

It was a curious relic to find in such a place,—close upon the water's edge. The Welsh people used to relate that in that neighbourhood there had been a palace of Llewellyn, and some remains were pointed out as the foundations of the house. The cave had the appearance of having been a retreat, probably, in a garden attached to the residence of some person of wealth, for its decoration was costly and handsome.

Some, I am told, are of opinion that it was an appendage to Gogarth Abbey; this it is attempted to prove by some traces of a footpath between the old abbey and the cave, which are still visible on the green slopes of the mountain.

on the other, the slopes of Penmaenbach and Penmaenmawr forming the chief feature in the boundary of the southern side. Some idea of the great beauty of this vale may be obtained from what remains of it at Llanvairfechan, and on from thence to the Menai Straits. The valley in which Llandudno is principally built lying between the Great and Little Ormesheads, formed part of it, as well as the marsh which extends for a considerable distance below Conway. Included within the boundary, and rising from the plain, is Priestholme, now Puffin Island. It is said also that Helig ab Glanawg, a relative of the ancient princes of Wales, had a residence and lands in this vale. The foundations of the house Llys Helig, or Helig Hall, still remain, and are to be seen twice a year at the lowest tides. Last Summer, while in Wales, the Rev. Richard Parry, of Llandudno, brought to me an old magazine, in which had been published a paper which embodied the local traditions. The paper had been drawn up by a Welsh clergyman, for the purpose of preserving them, and had been retained in his family as a document of value. A lady, a descendant of the clergyman, was the last possessor of it, and having attained a great age, she had it published in the magazine I refer to, I think in the year 1830, in order to put the traditions upon record, and to prevent them being lost as recorded in the paper of her ancestor. I read it carefully at the time several times, but, for the sake of accuracy, I have obtained the *ipsissima verba* of the record, so far as it relates to the locality under consideration.

"There is a very ancient legend or historical tradition of the inundation of the land of Helig ab Glanawg, or Morfa Rhianedd, between the Great Ormeshead and Priestholme, still extant, preserved also in ancient manuscript.

"Enion ab Cynedda Wledig, (*i.e.*, the popular,) who was lord of Caer Einion, had issue Llyr Merini, who had issue Caradoc, surnamed Vreichvras, (strong arm,) called

by the Saxons the Strong, or Caradoc the Valiant, who, in right of his wife Guiniver, was afterwards king of North Wales, who had many great conflicts with the Romans. Caradoc had issue Gwgan Gleddyvrudd, (*i.e.*, Gwgan with the bloody sword,) who had issue Glanawg, father to his son Helig ab Glanawg. This Helig was lord of Abergele Rhos, Arllechwedd Lleyn, Cantref Gwaelod; and he was also Earl of Hereford. In his time happened the great inundation which surrounded Morfa Rhianedd, the most delicate, fruitful and pleasant vale, lying from Bangor, Vawr yn Ngwynedd, to Gogarth, and so to Tyganwy, or Gannoc Castle in length, and in breadth from Dwygy-fylchi to the point of Flintshire, which came up from Rhuddlan to Priestholme, and in the upper end whereof did extend in breadth from Aber and Llanvair to the River Ell, which did divide Caernarvon from Môn, and did likewise divide Môn from Flintshire, running between Priestholme and Penmon, and so discharging itself into the sea a great way beyond Priestholme, and did surround many other rich and fruitful bottoms and vales within the counties of Caernarvon and Flint and Môn and Merioneth, most of them being the land of Helig ab Glanawg, whose chiefest palace stood in this vale, much about the middle way from Penmaenmawr and Gogarth. The ruins are now to be seen upon a ground ebb, some two miles within the sea, directly against Trwyn yr Wylfa, or point of wailing, which is a hill lying in the midst of the parish of Dwygyfylchi, within the land of Sir John Bodvel, Knight, unto which hill Helig ab Glanawg and his people did run up to save themselves, being endangered with the sudden breaking in of the sea, and there saved their lives. And being come up to the point of that hill, and looking back, beholding that dreadful and ruthful spectacle which they had so survived and looked upon, instead of their incomparable vale, which did abound in fruitfulness,

and excelling all other vales in this part of England in all fertility and pleasantness, Helig ab Glanawg and all his people, wringing their hands together, made a great outcry, bewailing their misfortune, and calling unto God for mercy, the point of which is called to this day Trwyn yr Wylfa, the point of the doleful hill."

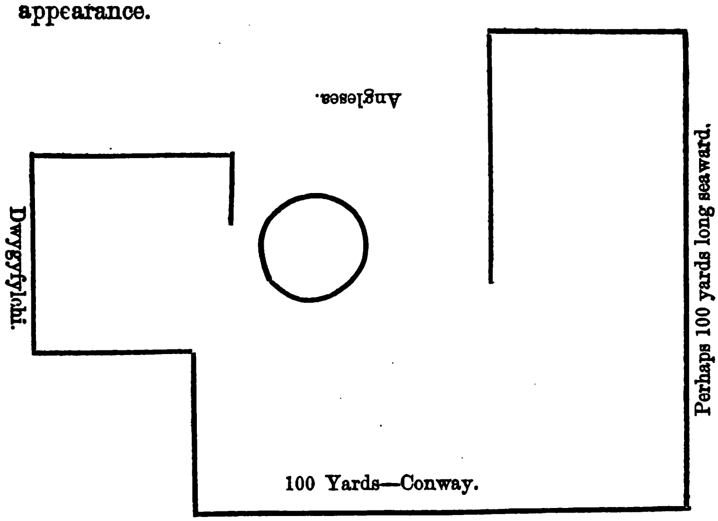
The Rev. Richard Parry says it is mentioned in the Jolo MSS., page 419, that "In 331 sea and land floods occurred coincidently, when the territory of Helig, the son of Glanog, of Tyno Helig, was inundated and irrecoverably lost."

The name of this Helig ab Glanawg, like that of Gwyddno Garanhir, lord of the lowland Cantre'r, is scarcely ever mentioned without this additional observation, "whose land was overwhelmed by the sea," which states a circumstance that is not only confirmed both by oral tradition and record, but also by the local appearance of its asserted position, the description of which in the text, although involved in obscurity, seems to indicate that it extended from the mouth of the Clwyd to Beaumaris Bay.

Such is the tradition, and coming up so distinctly in the record of it in the magazine I have referred to, I resolved, along with my friend the Rev. Richard Parry, to make a search for the ruins on the first day that the tide would fall low enough to lay them bare, and so to test the truth of the story. So far as I know, no visit had been previously made to the spot for twenty years. In Lewis Morris's maps the first survey made, by the appointment of the Government, of the Welsh coast, the foundations of the old mansion of Llys Helig are marked. Guided by this map, and by Mr. Hugh Roberts, the owner of our boat, who some twenty years ago visited the spot, I, in company with the Rev. Richard Parry, of Llandudno, the Rev. Thos. F. Fergie, incumbent of Ince, Wigan, and Mr. Hugh Roberts and his son, started on our voyage of dis-

covery, from the landing-place in Llandudno Bay, about two o'clock in the afternoon on the 19th August last. It was a beautiful afternoon, with a moderate breeze from the northward. The wind being in this quarter, we had to pull round the Great Ormeshead, but the slowness of our progress was compensated by the opportunity it afforded of inspecting the effects of the sea upon the headland, and we were also able to run into an indentation of the rock, where there is a cave, and where the Head receives the full force of the advancing tide, when the wind from the north hurries it with violence and impetuosity against the opposing rock. When past the Head, and fairly into the Conway, or Beaumaris Bay, we put up sail and stretched across towards Penmaenmawr, and we reached the ground where we supposed we should discover the ruins between four and five o'clock. We sailed backwards and forwards in front of Trwyn yr Wylfa, keeping a sharp look-out in all directions until the time of low water had arrived, but our search was all in vain, and doubts began to creep over our minds. I was steering, and bearing in mind that the ruins are said to be seen directly against Trwyn yr Wylfa, I put the head of the boat out to sea, and running directly out from that point, I thought that if the ruins were to be seen at all, we must in that way come across them. The fact was, we had been searching too close inland. We had not run out seaward long when the boatmen called our attention to a black mass upon the surface of the water, and over which it was breaking. We made all speed, and quickly came up to the object of our search. All we could see, however, was sea weed running in regular lines. Running up into and alongside the sea weed I found, by taking off my coat and stripping my arms, that the weed grew upon the top of what appeared to have been a wall. I pulled up some of the stones; some were too large to be dislodged, but by pulling slowly along the line of weed it

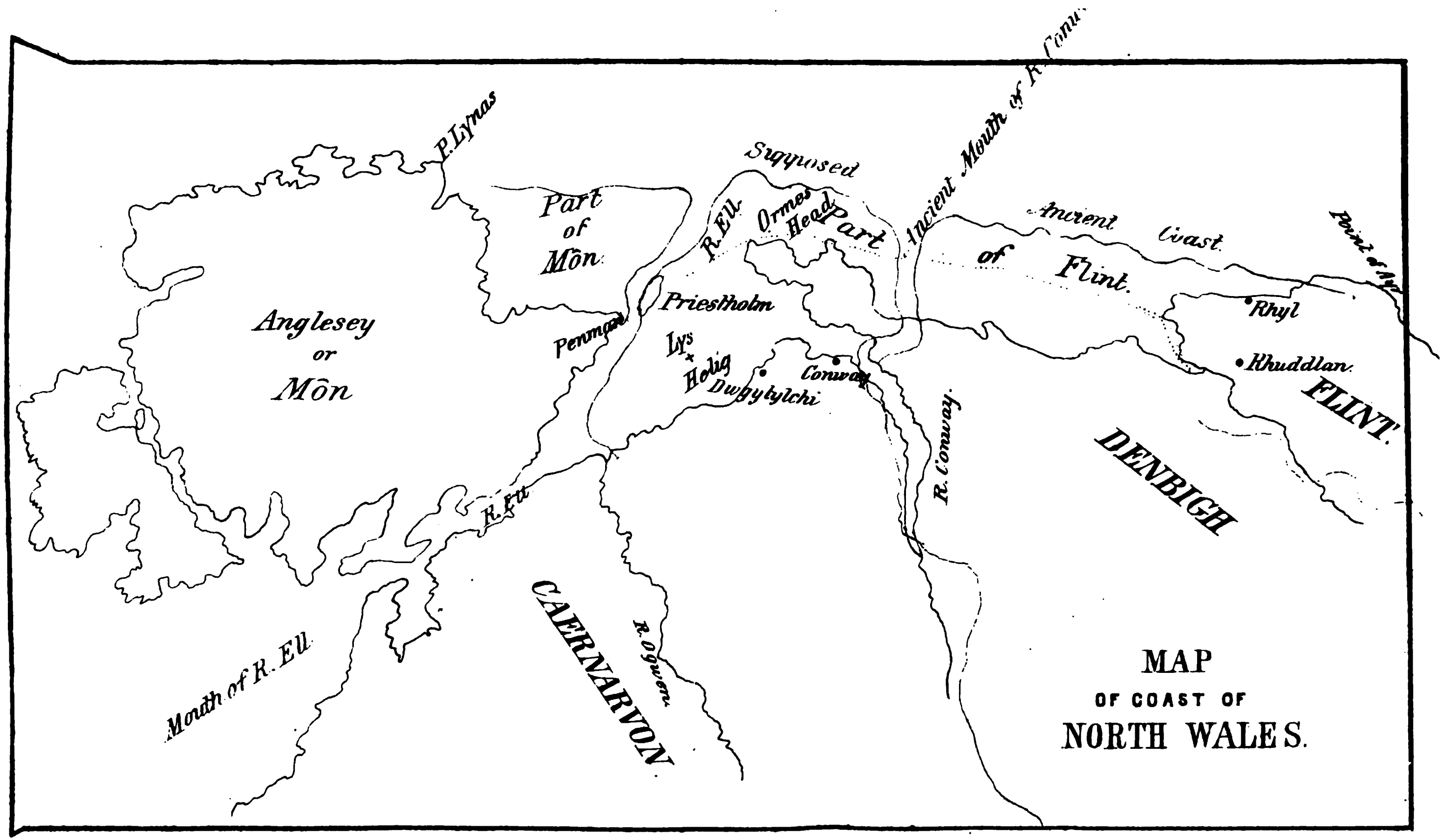
became evident that the stones ran in straight lines, and, so far as could be judged by feeling, they appeared to be just as the stones of a wall would be after being thrown down by the action of the sea, until those on either side would support the rest. To test this, I found that our boat just floated on the top of the stones, sometimes grounding, but, in pushing off a little, on either side there was perhaps five or six feet water. There appeared to be a centre part, free from stones, and we pulled the boat round into it, and on trying the depth of water it was about six or seven feet. It was a place which, looking at the lines of sea weed on the surface, indicated a court-yard, or the interior of a large apartment. It was quite low water when we reached the spot, perhaps rather after, and the tide was rapidly making, so that we had little time for investigation. Under these circumstances, I hurriedly sketched the outline on the back of the book containing the maps, and the following is a faithful description of the appearance.



Having no idea of the nature of the appearance of the place and of the circumstances, we were quite unprepared

for a satisfactory examination, otherwise we might have taken measurements and determined more accurately the character of the structure. As it was, there did appear in the outline of the structure—in the straight lines—in there being in the inside of the lines deep water—evidence of the truth of the legend that there, on that spot—now covered by the sea, and at least two miles out from the nearest land—did once stand a grand old hall of magnificent dimensions, of whose shape and proportions there still remain distinguishable traces.

The Rev. Richard Parry has published an account of our visit in the Welsh papers, of portions of which he has sent me a translation. It may be well to compare his statements. He says, "We reached the place when the water-mark was near the lowest ebb, when we had a full view of the place, and Mr. Hall drew a sketch of the foundations. He also managed to take a few stones from the wall, which were taken to shore as monuments of the ancient edifice and of the successful voyage. The sides were quite visible in every compartment of the place. Where the stones were under water the sea weed made up the deficiency, and we found no difficulty in tracing the whole. The short time of the low ebb did not allow time for the admeasurement, although a tape for the purpose was provided. It is presumed the following is not far from the mark:—The long angle fronting the north or the great sea was about 100 yards, and all the others of comparative lengths. It had all the appearance of the remnants of an old palace and its appurtenances. The house fronting the south, towards Dwygyfylchi, the garden facing the north, and the tower in the centre. All the ancient Welsh towers were of a circular shape. The distance from Gogarth to the spot is about four or five miles, and from Dwygylfylchi shore two miles." In his remarks on the Conway Bay, Lewis Morris says, "A buoy is much wanted on that patch of foul ground called Llys Helig ab Glanawg."


MAP
OF COAST OF
NORTH WALES.
FLINT.
DENBIGH
CAERNARVON.
Anglesey
or
Môn
Part
of
Môn
P. Lynas
Supposed
Part
Ormes
Head
R. Ell
Priestholm
Penmaen
Lys
Helig
Dwygyfylchi
Conway
R. Conway.
Ancient Mouth of R. Conw
Ancient
Coast
of
Flint.
Point of Ayr
Rhyl
Rhuddlan
R. Ell
R. Ogwen.
Mouth of R. Ell

It now becomes necessary to notice some of the other and more difficult portions of the legend. At first sight, and looking at our existing maps and divisions of the country, the whole appears to be a mass of confusion and utterly unintelligible. So I thought it, after reading the tradition over and over again. I had, however, previously in my mind a conviction that from the Point of Ayr, at the mouth of the Dee, to Point Lynas, in Anglesea, there had stretched a plain at some remote era, over which the sea now washes. There is some evidence that the coast line has extended further seawards than it does now within a comparatively short date. There is, for instance, in the churchyard at Abergele, a tombstone, on which it is stated that the person thereunder interred lived three miles northward of the spot. The tide, as you know, now washes up to within one mile of Abergele. Then there is the church of St. Tudno, on the Great Ormeshead, of which I have spoken. Well, then, if this be so, and with the fact that the sea is still encroaching in that direction, it may be within the limits of reasonable conjecture that the coast line was very much further north even within the historic period. The tradition states that Morfa Rhianedd, which was inundated, extended in breadth from Dwygyfylchi to the point of Flintshire, which came up (that is, Flintshire came up) from Rhuddlan to Priestholme. Looking at Flintshire, as drawn upon our maps, this is impossible; but if the lands have been washed away which constituted a portion of Flint, there is no impossibility in Flint having come up to point at Priestholme, (as shown by extending the coast line upon the map.)* Then the vale is said to have extended in another direction, from Aber and Llanvair to the River Ell, which River Ell at that time divided

* See the map prefixed. The lands supposed to have been washed away or inundated are included within the red lines, the existing coast lines being drawn in black. The course of the extinct river (Ell) is also shown, as well as the supposed ancient outlet of the Conway.

Caernarvon from Môn, (Anglesea,) and likewise divided Môn from Flintshire, running between Priestholme and Penmon, and that it discharged itself into the sea a great way beyond Priestholme. This River Ell has now altogether disappeared, unless it may have formed a fork at the point of Anglesea, opposite Bangor, and that the bed of the Menai Straits was one of its outlets, that dividing, according to the tradition, Caernarvon from Môn, and the other outlet running along the eastern side of Anglesea, and between it and Priestholme, and so dividing Anglesea from Flintshire. This river may have been a stream joining the Ogwen at or about where that river now discharges itself, or the Ogwen from that point may have taken the name of Ell. Certain it is that no such river now exists, and, indeed, if the traditional inundation did occur, no such river could exist, for flowing, as it did, in an open valley, it would be absorbed in the common flood, while through its outlet now forming the Menai Straits, the sea would wash, as it does now, from Caernarvon Bay to Beaumaris Bay. There are at Llanvairfechen the clear marks of the banks of an extinct stream, which may have been the tributary that gave the name of Ell to the outlet of the Ogwen.

There is another confirmatory conjecture, and one entirely consistent with the tradition of a deluge, inundation, or flood of this valley and of the coast land, to which allow me to call your attention. A careful examination of the River Conway, and of the country to the east and north of Llansaintfraid, will serve to point to the conclusion that the River Conway discharged itself originally through a valley which runs eastward of the Little Orme. The course would seem to have run from below Llansaintfraid past Mochtrai, along a portion of the valley through which the Chester and Holyhead Railway now runs, and then, turning in a northerly direction, down

to the sea. The lie of the country is the chief ground upon which this conjecture rests, but the village of Mochtrai derives its name, as I am told, from two words, which indicate the flow of the river past it, *Moch* signifying quick, and *trai* tide,—Mochtrai, or quick-tide. The land at this place would show that the tide would ebb and flow rapidly here, and these circumstances are an element in proof that this was the original course of the river.* Now the inundation of the vale below Conway would contribute, with the action of the river itself, to change its course into the present channel, while this outflow of the river would assist in the more perfect submergence of the vale.

I have thus endeavoured, with as much clearness as I have been able, to draw your attention to the probability of the ancient coast line of North Wales having extended far beyond its present limits. I should, however, greatly mislead you if I have conveyed the impression that the whole of the vast change which has occurred has taken place within the historic era. This is in the highest degree improbable. It is not so that the laws of change operate. For the most part their action is silent, slow, and unobserved, and it is only after long cycles that the effects of change become apparent, and that we become aware that the most enduring and stable of the works of God are in course of mutation, and are passing into new forms. Not only is it true that man passes away, and that the place that knew him knows him no more, but it is equally true that the place he knew passes away and becomes unknown. The most solid emblems of duration and stability change,—the vault of night, that discloses its

* I am told that the names of farms and localities hereabouts also lend confirmation to this conjecture.

splendid panorama of revolving worlds, is changing;—

> The great globe itself,
> Yea, all which it inherit, shall dissolve,
> And, like an unsubstantial pageant, faded
> Leave not a wreck behind.

There is only One who changes not,—He "Who hath measured the waters in the hollow of His hand, and meted out heaven with the span, and comprehended the dust of the earth in a measure, and weighed the mountains in scales and the hills in a balance;" and "Who hath gathered the wind in His fists:"—Awfully majestic in His unchanging nature, in the presence of His works, which ever change and are changing, we admire, wonder, and adore.

THE GEOLOGY OF THE COUNTRY AROUND BUILTH.

By R. A. Eskrigge.

The little market town of Builth has attractions for the lover of the picturesque as well as for the geologist, being prettily situated on the banks of the Wye, at the south-western foot of the Carneddau hills, in an alluvial valley, formed by the shifting of the bed of the stream.

The geological formations visible in the neighbourhood are exclusively Silurian, and will be briefly described in ascending order. The Llandeilo beds, which are the lowest stratified deposits, are chiefly exhibited on the flanks of the Carneddau hills, which extend from Llandegly and Llandrindod, eight miles N.E. of Builth, to half a mile south of the latter town. The greatest breadth of this tract is two and a-half to three miles.

As in most other localities where this formation assumes any important development, the strata are much broken and contorted, and there is abundant evidence that

they were deposited during a period of volcanic activity, in fact, the surface of the larger portion of the tract above described is occupied by igneous rocks, the softer shales being generally denuded, except in the valleys. Most of these igneous rocks are contemporaneous with the stratified deposits, being interbedded with them, and occasionally containing similar fossils. All such trap-rocks are, more or less, felspathic; sometimes porphyritic, at other times of the character of volcanic ash. Some of the more compact greenstones near Builth, however, are almost certainly of later date, since they contain large masses of shale, which have evidently been consolidated before their entanglement. These probably belong to the period when the strata were thrown into their present highly inclined position.

The strike of the Llandeilo beds is N.E. by S.W., conforming with that of the strata generally in this part of Wales, and, indeed, looked at broadly, and allowing for local variations, with that of most of the rocks of the southern portion of the island.

Apropos of this point, it is interesting to note that almost all the lines of igneous outburst, both in North Wales and Shropshire, maintain a similar course, whether the volcanic action have taken place during the deposition of the strata or at a later period, showing that the deep-seated lines of igneous force are constant in their direction. The great fault east of the Longmynd also runs for forty-five miles in the same direction.

The lithological character of the true Llandeilo beds varies considerably, being often much altered near the trap. At Gwern-y-Fod the strata are thrown into an almost vertical position by a mass of greenstone, which has hardened the rock into a silicified flagstone, of a burnt black colour. The beds vary from half-inch to two inches in thickness, and are in many places highly charged with iron pyrites. Fossils are abundant. At Wellfield the beds are

sometimes two feet in thickness, and the rock is a light grey, compact, calcareous sandstone, jointed into irregular prisms and generally free from metallic indications, though it sometimes shows traces of iron.

Further north, again, at Pen-cerrig, the rock changes to a black argillo-arenaceous shale, weathering brown, in an extremely fragmentary state, owing to the dislocation caused by the greenstone which is here protruded, evidently since the deposition of the strata. The fossils obtained from these three localities are:

Ampyx nudus, (peculiar to the Builth district.)	Graptolites tenuis.
Calymene duplicata.	Grap. priodon.
Ogygia Buchii.	Diplograpsus sp.
Ogygia Portlockii.	Didymograpsus Murchisoni.
*Asaphus Corndensis.	Lingula plumbea.
Trinucleus fimbriatus.	Lingula attenuata.
Trin. Lloydii.	Siphonotreta micula.
Agnostus Maccoyi.	Orthoceras, 2 sp.
	Bellerophon sp.

* This species occurs further north, near Llandrindod.

Near Builth and also at Llandrindod there are wells much resorted to for their medicinal properties. At Builth there are two springs, the one chalybeate and the other sulphurous, rising not many yards apart. The latter comes from the shales in contact with the greenstone, and it is shown by Sir R. Murchison in his Silurian System that it derives its mineral properties from the sulphuret of iron with which the rock is charged. The former springs from the unaltered shales, which contain only the oxide of iron.

The black colour of the shale has in several instances given rise to the belief that there must be coal beneath, and much labour and money have been fruitlessly expended in its search. A few traces of anthracite near to the trap have favoured the delusion, (Murch. Sil. Sys.) Some nine miles E. of Builth the Llandeilo rock is again brought up,

through the overlying Llandovery beds, by a fault, extending four miles in a N.E. and S.W. direction. The physical phenomena are similar to those already described, though few fossils occur there.

The next formation in ascending order is the Upper Llandovery, which runs in a narrow band between the Llandeilo and the Wenlock. Though unconformable to the former, the dip is not greatly different, showing that no great disturbance of the strata occurred between the times of their deposition, though that period was probably a long one. The rock is a coarse-grained sandstone, sometimes conglomeratic, containing a few fossils, chiefly *Pentamerus* and *Petraia*. It may be seen at Gwern-y-Fod, and also at the back of Pen-Cerrig House, in junction with the greenstone. A small bed of it has also been tilted over during the upthrow of the strata into the midst of the Llandeilo shales.

The Wenlock beds are largely developed, overlapping the Llandeilo shales on all sides. Near Builth the difference of dip is not great, but further north the Wenlock lies on the nearly vertical edges of the lower rock, another of those interesting proofs by which the geologist is forced to the belief that vast intervals of time must have elapsed between deposits geologically near together.

The Wenlock shale varies from a dark blue to a brownish levigated mudstone, sometimes becoming gritty. There are no continuous beds of limestone, but the Wenlock Limestone is represented by bands of calcareous nodules, sometimes of large size. Fossils are tolerably abundant.

Above the Wenlock beds, both to the east and south, come the Ludlow rocks, which are similar, both in lithological character and in their fossils, to those of the typical district whence the formation derives its name.

At Mynydd Aberedw, four miles from Builth, there is a fine section in the lofty and picturesque cliffs bounding the river valley. The beds dip gently to the S.E., and representatives may be distinguished both of the Upper and Lower Ludlow and of the intervening Aymestry Limestone. Some good fossils are found here, including *Homalonotus Knightii*, a *Lituites*, and what appears to be *Illænus Barriensis*.

Such is a brief summary of the phenomena presented to the geologist, and it only remains to trace hastily the various changes of which we here have the records. Going back, then, to the "Llandeilo;"—this was certainly an age of great volcanic activity, but with long intervals, during which the subterranean forces were quiescent. At such times the aqueous deposits were tranquilly spread over the bottom of a deep sea, of high temperature. Then came periods when the submarine volcanoes poured forth molten ashes and lava, altering the beds with which they came in contact. Such alternations of quiescence and activity were frequently repeated, and extended over long periods, as the Llandeilo series is of immense thickness.

At the close of the Llandeilo age this tract was probably elevated, and remained above water during the long period during which the Bala beds were being deposited further north. After the Bala beds the Lower Llandovery strata were laid down in a shallower sea to the westward, the Carneddau being still dry land, but gradually subsiding. The "Upper Llandovery" is generally regarded as a littoral deposit, and is laid unconformably upon the flanks of these hills, which may have formed the cliffs of the Western Sea, or perhaps an island in it. There was then, probably, a renewal of volcanic disturbance, and it is to this period we refer the greenstones near Pen-Cerrig and Builth. A long period of subsidence ensued and a corresponding cessation of volcanic activity, and when the heights

of the Carneddau had again become the bottom of a deep sea, the Wenlock and Ludlow groups of strata were deposited without much disturbance. Whether the Old Red formation was also continuous over this tract is doubtful, but still highly probable, from the outliers occurring to the north.

The amount of denudation which would thus be rendered necessary is enormous, but, when we remember that Mr. Ramsay estimates that in some parts of North Wales no less than 31,000 feet of solid strata have been removed, we need not be staggered at our more moderate requirements. Of the agencies by which such vast changes have been wrought we must not now speculate. As yet we only possess a few fragments of the ancient manuscripts wherein Nature's great Author has recorded his operations, and we are only beginning to interpret the hieroglyphics in which they are registered. Let us work in the spirit of the great philosopher who said in substance, if not in exact words, "He who aspires to become Nature's master must first sit at her feet, and content himself with being her humble disciple."

NOTE.—The paper was illustrated by sections enlarged from those of the Ordnance Survey. Hor. sections, sheets 5 and 6.

JANUARY 10TH, 1865.

THE PRESIDENT, HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S., in the Chair.

ROBERT COLTART was elected an Ordinary Member.

The following communications were read:

ON THE RECENT SHELL-BED AT WALLASEY.

By George H. Morton, F.G.S.

A stratum of recent shells has been long known and exposed, near the village of Wallasey, in Cheshire. Some observers of the deposit have attributed it to marine agency, and have considered that the shells were left by the sea, as it retired to a lower level. Others have supposed the shells to be an ancient accumulation resembling the "Kjokenmoddings" in Denmark.* The author stated that neither of these conclusions could be correct, and that the deposit in question is of very recent date.

Just above the village there is a bank of rock (Keuper) bounding the road, which has been excavated along the side of the hill, about a hundred yards to the south of the ruins of the old church tower. This bank is about twelve feet high, the shell-bed rests directly upon it, and is covered by several feet of vegetable mould, the surface of which forms a small garden. A few yards to the east is a dilapidated building, about two hundred years old, which was formerly an inhabited house, with farm offices attached. Except in the garden referred to, there is only a very bare covering to the sandy-rock, and the shells occur in just such a position as that in which they might have been thrown with other refuse from the house, before the soil of the garden was brought and spread out over them. That this superincumbent soil has been brought from a distance is evident on examining the ground, while the number of fragments of tobacco pipes and old blue crockery embedded

* The Ancient Fauna of Lancashire and Cheshire, by Cuthbert Collingwood, M.A., F.L.S. Proceedings Literary and Philosophical Society of Liverpool, No. 17, 1862-3, page 113.

in it, from the shells upwards, clearly indicates the age of the deposit as being very recent.

The shell-bed is principally composed of the shells of two edible Mollusks, viz., the mussel, *Mytilus edulis*, and the whelk, *Buccinnum undatum*. The former often broken and always free from the epidermis, and the latter species unbroken, and including many small specimens. The periwinkle, *Littorina littorea*; the cockle, *Cardium edule*; and the snail, *Helix aspersa*, also occur, with a few mammalian bones. The bed is about six inches thick, and only extends a few yards, but as it thins away gradually, its extent is not clearly defined. The author stated that he had minutely examined this shell-bed, with the circumstances connected with it, and concluded that it had originated since the contiguous building was erected, and that, like many other other similar accumulations that frequently come under the notice of geologists, was of no geological importance.

A GEOLOGICAL RAMBLE IN IRELAND.

By Hugh F. Hall.

After referring to the Cambrian rocks of Bray Head, and exhibiting their characteristic fossil, *Oldhamia radiata*, the author called the attention of the Society to the existence of an ancient sea margin, extending northwards from Bray for many miles, which he considered the equivalent of those mentioned by Mr. Robert Chambers as occurring at Fortwilliam and other places in Great Britain at 32 feet. He then entered on his main subject, the geology of the

coast from Ballycastle to Belfast, embracing the northern and eastern boundaries of the great trappean area of the north-east of Ireland. The stratification of Fairhead, whose almost perpendicular cliffs afford a fine section, was described as consisting at the base of carboniferous shales of considerable thickness, (in one bed of which very fine specimens of a *Lingula* and the wing case of an insect were obtained.) In these beds numerous borings for coal have been made, but with no commercial success, though, where a large deposit of ironstone is worked, it is found there is sufficient carbon to continue burning when once thoroughly ignited. In this way about 200 tons of iron ore a day are prepared for shipment to Scotland, where it is smelted. Above the shales greyish carboniferous sandstones are developed, containing *Stigmaria ficoides* and several plants, resting on which is the basalt which forms the top of the cliff. Numerous trap dykes occur all along the shore, between two of which the mountain limestone has been pushed up, being exposed on the shore at low water for about 50 yards.

On the eastern side of Fairhead, in Murlagh Bay, another section is exposed, the overlying trap having been denuded from the summit, where the hard chalk, containing *belemnites*, takes its place; but descending the cliffs, as Fairhead is neared, the columnar basalt is developed in a very fine series of columns, an immense mass of which has fallen and filled up the middle of the bay. Below the chalk a narrow band of Greensand, a few inches thick, was met with at one point, below which again the carboniferous sandstones occur, the shales met with on the western side being much more largely developed at the base. The horizontal lie of the strata in the white cliffs of Rathlin Island, which lies opposite this point, crowned with black basalt, while indicating that it had once been connected

with the mainland, would show that it had escaped the influence of the convulsion which has lowered the Giant's Causeway into the sea, and left the chalk of Murlagh cliffs exposed at 700 feet above it. The drive from this place to Tor Head reveals the presence of an extensive deposit of drift, the rivers having cut through it in some places 70 or 80 feet. Tor Head lies amid the so-called Cambrian rocks which run along the coast for several miles, till the picturesque scenery of Cushendun and Cushendall reveals the Old Red Sandstone, forming cliffs 200 to 300 feet high, and varying from a very coarse conglomerate, composed of pebbles, measuring 2 feet in diameter, to very finely comminuted sand. A dyke of fine porphyry and one of a black porphyritic trap, exhibit themselves in this formation. Proceeding south, we again come upon the basalt, at Garron Point, semi-columnar, covering the chalk, below which it is presumed that the Lias is developed, as an extensive land-slip has at that place brought down the overlying trap nearly into the sea. Carnlough Bay, beyond Garron Point, is again a hollowing out of the sandstone, but here it is the New Red Sandstone lying immediately below the Lias, the country behind exposing the New Red Sandstone underlying the Chalk, which is capped by the edges of the trappean surface. Further south, in Glenarm Bay, the strata show themselves as follows—New Red, Lias, Greensand, Chalk, and trap, which order maintains itself for the next forty miles, right up to Belfast, the noticeable exception being the long low peninsula forming the seawards boundary of Larne Lough, which consists of a great development of Lias and Greensand, with a belt of trap occupying the centre, the Chalk exhibiting itself at White Head, at the southern extremity.

The paper was illustrated by specimens of the fossils and rocks referred to, and the exhibition of the head and horns of a fine specimen of *Megaceros Hibernicus*, found in

the shell-marl under the peat of Island Magee, shortly before the author's visit, and described by Mr. William Gray, in a paper read before the Belfast Naturalists' Field Club. Ballygally Head presents the largest development of columnar basalt seen along the coast, the joints being 8 to 10 feet apart.

FEBRUARY 14TH, 1865.

R. A. ESKRIGGE, Esq., Vice-President, in the Chair.

The Rev. James Cranbrook, Jun., Thomas Jones, and Charlton R. Hall were elected Ordinary Members.

The following communications were read:

LIST OF FOSSILS DESCRIBED FROM THE BALA LIMESTONE AND ITS ASSOCIATED BEDS OF NORTH WALES.

By D. C. Davies, of Oswestry.

This list of fossils is intended to accompany and illustrate my paper on the Bala Limestone of North Wales:* the list is confined to those discovered in the beds described in that paper, and refers to North Wales only. The localities in which many of the fossils have been found are more numerous than those given in the list, but I have named the principal places, and have given the preference to those known to myself. The reader will remember that the term Limestone, as here used, is a very general one, and is intended to represent the Bala Limestone in all the

* Abstract Proc. Liver. Geol. Soc., 1863-4, fol. 21.

varieties of its lithological structure referred to in my description of it. It has not been any part of my purpose to follow any of the fossils into overlying groups of rocks, but I have been careful to fix the lowest point at which the fossils have as yet been found. I have endeavoured to make the list as complete as possible, but I feel sure that there are still many undescribed fossils from this group scattered through various collections. The Univalve and Lamellibranchiate shells especially may, I think, be increased considerably. The authors' names are given. There are many interesting topics relating to the grouping of the fossils, the antiquity of certain forms, and the correlation of the whole to similar beds elsewhere developed, but these must be left to the reader to work out for himself.

ZOOPHYTA.

Name of Fossil.	Localities.	Strata in which found according to section.
Graptolites species	Llanfyllin	Middle beds
Diplograpsus pristis, His.	Glyn Ceiriog, Conway	Shale beds, above the upper limestone
Protovirgularia dichotoma, M'Coy	Cefn Coch, Nantyr, in Glyn Ceiriog	Uppermost shale beds
Heliolites interstinctus, M. E.	Ditto	From mid limestone to uppermost schists
,, petalliformis, Lons.	Ditto	Schists between second and third limestones
,, tubulatus, Lons.	Ditto, and Allt Goch, Llanfyllin	Mid limestone
,, megastoma, M'Coy	Moelydd, near Oswestry, Bala	Ditto and uppermost shale
Favosites alveolaris, Gold.	Meifod, Llanfyllin	Ditto and schists above it
,, Gothlandica, Linn.	Moelyd	Shale equivalent of top limestone
Nebulipora explanata, M'Coy	Cefn Coch, Glyn Ceiriog	Uppermost schists
,, lens, M'Coy	Pont y Glyn, near Corwen	Mid limestone and schists above
Stenopora fibrosa lycopodites, Gold.	Glyn Deirw, Glyn Ceiriog	From lowest to uppermost limestone and overlying schists
Halysites catenularius, Linn.	Glyn Ceiriog	Mid limestone to topmost schists
Petraia æquisulcata, M'Coy	Ditto	Topmost schists
,, elongata, Phillips	Bala	Mid beds
,, subduplicata, M'Coy	Glyn Ceiriog, Cyrnybrain, North of Llangollen	Ditto
,, uniserialis, M'Coy	Ditto, Moelydd	Topmost schists
Ptilodictya acuta, Hall	Llechydd Llwyd, near Llanrhaider, Glyn Ceiriog	Mid limestone and schists
,, costellata, M'Coy	Mathyrafal, near Meifod, Glyn Ceiriog	Ditto
,, fucoides, M'Coy	Cefn Coch, in Glyn Ceriog	Mid and top schists
,, lanceolata, Gold.	Moelydd shale, near Oswestry	Equivalent of top limestone
Retepora Hisingeri, M'Coy.	Cefn Coch and Fronfrys, in Glyn Ceiriog	Mid and top schists
Glauconome disticha. Gold.	Glyn Ceiriog, Llanfyllin	Ditto
Fenestella Milleri, Lons.	Ditto	Ditto
,, subantiqua, D.Orb.	Ditto	Ditto

ECHINODERMATA.

Name of Fossil.	Localities.	Strata in which found according to section.
Glyptocrinus basalis, M'Coy	Allt yr Anker, Meifod	Mid limestone and schists
,, species	Moelydd	Top beds
Uraster obtusus, Forbes	Moel y Garnedd, W. of Bala lake	Lowest limestone
Ophiura Salteri, Edgeworth	Penypak	
Palæocyclus	Llanfyllin	Mid limestone
Echinosphærites Balticus, Forbes	Ditto	Ditto
,, undatus	Bala	Uncertain
Caryocystites munitus, Forbes	Ditto	Ditto
,, species	Das Eithen	Mid limestone
Ischadites tessellatus, Salter	Cefn Coch, in Ceriog Glyn	Uppermost schists

ARTICULATA.

Tentaculites annulatus	Glyn Ceiriog	Uppermost schists
,, tenuis, Sow.	Ditto	Ditto
Beyrichia Klodeni, M'Coy	Dermyddfawr, near Corwen	Uncertain
,, complicata, Salt.	Glyn Deirw, Llanfyllin, Glyn Ceiriog	From lowest to mid limestone Mid schists
Cythere umbonata, Salt.	Gelligrin, near Bala	Mid limestone
Trinodus agnostiformis, M'C.	Rhiwlas, near Bala	Ditto
,, tardus, Baronde	Ditto	Ditto
Trinucleus Caractaci, Murch.	Welshpool, Glyn Ceiriog	Upper schists
,, gibbifrons, M'Coy	Llanfyllin, Meifod	Mid limestone
,, latus, Port	Glyn Ceiriog, Bala	Upper schists
,, undetermined	Glyn Deirw	Lowest limestone
,, radiatus, Murch.	Dinas Mowddy	Uncertain
Tretaspis fimbriata, Murch.	Bryn Melin, near Bala	Mid beds
,, seticornis, His.	Moelygarnedd, nr Bala, Meifod	Lowest to mid limestone
Ampyx nudus, Murch.	Near Llangynnog	Beds below mid limestone
,, tumidus, Salt.	Rhiwlas, near Bala	Mid limestone
Lichas nodulosus, Salt.	Pont y Glen, near Corwen	Schists upon mid limestone
Acidaspis Brightii, Murch.	Blaen y Cwm, Glyn Ceiriog	Ditto
Staurocephalus Murchisoni	Rhiwlas, near Bala	Mid limestone
Cheirurus clavifrons	Bala and Cefngrugos, near Llanfyllin	At Bala in mid limestone, at Cefngrugos in uprmst schists
,, tetrolobatus, M'Coy	Rhiwlas	Mid limestone
Encrinurus atractopyge, M'C.	Llanfyllin	Ditto
,, sexcostatus	Cefn Coch, Rhiwlas	At Cefn Coch, in top schists, at Rhiwlas in mid limestone
,, punctatus	Carnarvonshire	Uncertain
Phacops alifrons, Salt.	Cymmery, Bala, Pont y Glyn, Corwen	Mid limestone and schists
,, obtusi caudatus, Salt.	Cyrnybrain, N. of Llangollen	Uncertain
,, truncato caudatus, Port	Blain y Cwm, Nantyr.	Mid and upper schists
Phacops apiculatus, Salt.	Bala, Llanwddyn, Glyn Ceiriog	Mid limestone, uprmst schists
Asaphus Powisii, Murch.	Llanfyllin, Welshpool, Glyn Ceiriog	Ditto and beds below
,, tyrannus, Murch.	Llanfyllin, Llanhaider, Glyn Ceiriog	Mid limestone
Calymene Blumenbachii, Bron	Llanwddyn	Ditto
,, brevicapitata, Port.	Bala, Meifod, Cefn Coch, Llanfyllin, Bala	Mid and upper schists Mid limestone
Homalonotus bisulcatus, Salt.	Glyn Ceiriog	Uppermost schists
,, rudis, Salt.	Capelgarmon, Denbighshire	Uncertain
,, species, Salt.	Bryn Eithen	Ditto
Illænus Davisii, Salt	Bala, Llanwddyn, Moellydd	Mid and upper limestone and schists
,, latus, M'Coy	Cefn Coch, Clyn Ceiriog	Uppermost schists
,, Rosenbergii, Eich.	Cefn Coch, Blain y Cwm	Ditto
,, species	Moelydd	Equivalent of upper limestone
,, Bowmanii, Salt.	Llanwddyn	Mid limestone

BRACHIOPODA.

Name of Fossil.	Localities.	Strata in which found according to section.
Pseudocrania divaricata, M'Coy	Bryn Melin, Bala, Pont y Glyn, near Corwen	In schists over mid limestone
Spirifera insularis, Eich.	Llangyniw	Uncertain, may belong to Wenlock shale
,, percrassa, M'Coy	Cyrnybrain, Mathyrafal, near Meifod	Mid limestone and schists above
,, dentata, Pan.	Bala, Alltymaen, near Meifod, Moelydd	Ditto to uppermost schists
,, biforata, Schlot	Ditto	Ditto
,, lynx, Eich.	Ditto	Ditto
,, species	Pont y Glyn. near Corwen	Schists above mid limestone
,, fissicostata, M'Coy	Cefn Coch, Glyn Ceriog	Uppermost schists
Spirigerina marginalis, Dal.	Meifod, Llanfyllin, Bala	Schists above mid limestone
Hemithyris (Rhyn) depressa, Sow.	Bala	Mid limestone
Hemithyris diodonta, Dal.	Llanfyllin, Yspyttyevan	Ditto
,, hemispherica, Sow.	Moelydd	Uppermost beds
,, Lewisii, Dav.	Ditto, Mathyrafal	Ditto
,, rotunda, Sow.	Alltgoch, Llanfyllin	Mid limestane
,, subundata, M'Coy	Mathyrafal	Mid schists
Pentamerus globosus	Moelydd, Bettws y Coed	At Moelydd in uppermst beds
,, laevis, Sow.	Cyrnybrain	Mid beds
,, undatus, Sow.	Mathyrafal, Glyn Ceiriog, Llanfyllin	Ditto Mid limestone
Orthis Actoniae, Sow.	Moelydd, Llanfyllin	Uprmost beds, mid limestone
,, biloba, Linn.	Cefn Coch	Uppermost schists
,, callactis, Dal.	Bala, Welshpool	Mid limestone and schists
,, calligramma, Dal.	Moelydd, Clyn Ceiriog	Uppermost beds
,, *var.* calliptycha, M'Coy	Glyn Ceiriog	Limestone, uncertain
,, confinis, Salt.	Trowscoed, Gaerfawr, and Welshpool	Ditto
,, crispa, M'Coy	Cefn Coed, Glyn Ceiriog	Mid limestone
,, elegantula, Dal.	Wherever the beds are found in Wales	From the lowest fossiliferous beds, as seen in Glyn Deirw, to uppermost of the section
,, expansa, Sow.	Llanfyllin, Bala, Meifod, &c.	Lower to mid limestone
,, flabellulum, Sow.	Bala, Meifod, Glyn Ceiriog	Lowest to uppermost limestone and schists
,, grandis, Sow.	Bwlch y Cibau	Mid limestone
,, Hirnantensis, M'Coy	Pen y Garnedd and Valley of the Hirnant, Bala	Uppermost limestone
,, parva, Pan.	Bala, Glyn Ceriog, Llanfyllin, Llanwddyn, Dinas Mowddy	Mid and top schists
,, plicata, Sow.	Bala, Meifod, Glyn Ceiriog, Llanfyllin	Mid limestone and overlying schists
,, porcata, M'Coy	Glyn Ceiriog, Fenypark, Llanfyllin	Base of mid limestone
,, protensa, Sow.	Mathyrafal, nr Meifod, Cader Dinmael, near Corwen	Ditto
,, retrorsistria	Cerrigydruidion, Bala	Lower and mid limestone
,, ridgida, Dav.	Bala, Gaerfawr, nr Welshpool	Schists over mid limestone
,, sagittifera, M'Coy	Aber Hirnant, near Bala	Ditto over uprmst limestone
,, sarmentosa, M'Coy	Llyn Ogwen, near Capel Curig	Schists, horizon uncertain
,, testudinaria, Dal.	Penypark, Llanfyllin, Dollydd Ceiriog	Mid limestone and schists
,, turgida, M'Coy	Craig y Beri, near Llanrhaidar	Mid limestone
Orthisina ascendens, Pan.	Cyrnybrain, near Wrexham	Mid schists
,, Scotica, M'Coy	Llanfyllin	Uncertain
Leptaena alternata, Conrad	Moelydd	Uppermost beds
,, deltoidea, Conrad	Meifod, Cefn Coch	Ditto
,, *Var.* undata, M'Coy	Pont y Glyn	Mid limestone
,, laevigata, Sow.	Moelydd, Welshpool	Uppermost beds
,, quinquecostata, M'C.	Meifod	Mid limestone to schists
,, sericea. Sow.	Pont y Glyn, Llanfyllin, Glyn Ceiriog	Ditto to uppermost schists
,, tenuicincta, M'Coy	Moelydd	Top beds
,, tenuissimestriata, M'C	Cefn Grugos, near Llanfyllin, Moelydd	Mid and uppermost beds
Leptæna transversalis		
Strophomena antiquata, Sow.	Meifod, Nantyr in Glyn Ceiriog	Mid limestone&uprmst schists
,, funiculata, M'Coy	Cyrnybrain, N. of Llangollen	Mid schists
,, pecten, Linn.	Blaen y Cwm, Nantyr	Ditto
,, spiriferoides, M'C.	Llanfyllin	Ditto
,, depressa, Dal.	Meifod, Glyn Ceiriog	Mid limestone to top schists
,, ungula, M'Coy	Glyn Ceiriog	Ditto
Lingula attenuata, Sow.	Nant y Groes, near Bala	Sandy beds in mid limestone
,, Davisii, M'Coy	Ditto, Llanfyllin	Lower and mid beds
,, longissima, Pan.	Mynydd Fronfrys, Glyn Ceriog	Mid limestone
,, ovata, M'Coy	Moelydd, Das Eithen	Uppermost limestone
,, *tenuigranulata, M'C.*	Hills North of Llanfyllin, Das Eithen	Mid limestone and schists.

LAMELLIBRANCHIATA.

Name of Fossil.	Localities.	Strata in which found according to section.
Avicula Danbyi, M'Coy	Glyn Deirw, Glyn Ceiriog	Lowest limestone
,, orbicularis, Sow.	Ditto	Ditto
Pterinea pleuroptera, Con.	Cyrnybrain	Uncertain
Modiola antiqua, Sow.	Glyn Deirw, Gelligrin, nr Bala	Lowest limestone, mid schists
,, inflata, M'Coy	Llanfyllin, Bala	Sandy beds in mid limestone
,, modiolaris, Conrad	Hirnant near Bala, nr Corwen	Mid limestone to uppermost schists
,, expansa, Port.	Cerrig y Druidion	Lower beds
,, postlineata, M'Coy	Near Meifod, Glyn Ceiriog	Mid limestoue
Anodontopsis quadratus, M'C.	Glyn Deirw	Lowest limestone
Lyrodesma plana, Conrad	Yspytty Evan, N.W. of Bala	Uncertain
Clidophorus ovalis, M'Coy	Dolydd Ceiriog, S.E. of Corwen	Mid beds
,, planulatus, Con.	Llanfyllin and Glyn Ceiriog	Mid limestone
Orthonota nasuta	Ditto	Sandy beds in mid limestone
,, verisimilis	Alltygader	
,, semisulcata, Sow.	Main, near Meifod	Uncertain
Sanguinolites anguliferus, M'Coy	Ditto	Ditto
Leptodomus truncatus, M'C.	Ditto	Ditto
Grammysia extrasulcata, Salt.	Ditto	Ditto
Megalodon?	Glyn Ceiriog	Mid limestone
Arca Edmondiformis, M'Coy	Alltygader, Llanfyllin	Ditto
Nucula levata, Hall	Near Llangynnog	Lower beds
Nuculites post striata, Em.	Near Corwen	Uncertain

PTEROPODA.

Theca Forbesii, Sharp.	Glyn Ceirlog	Mid limestone

GASTEROPODA.

Pleurotomaria lenticularis, Sow.	Near Meifod	
Pleurotomaria turrita, Port.	Cyrnybrain	Mid and uppermost schists
Murchisonia cancellatula, M'Coy	Near Meifod	Mid and upper beds
Murchisonia gyrogonia, M'C.	Llanfyllin, Meifod, Glyn Ceiriog	Ditto
,, pulchra, M'Coy	Near Meifod	Ditto
,, simplex, M'Coy	Hills about Llanfyllin and Meifod	Ditto
Turbo crebristria, M'Coy	Penypark & Alltygader, Llanfyllin, Fronfrys in Glyn Ceiriog	Mid beds
Trochus constrictus, M'Coy	Bala	Schists above mid limestone
Euomphalus lyratus, M'Coy	Cefn Coch, Glyn Ceiriog	Uppermost schists
,, triporcatus, M'C.	Cyrnybrain, N. of Llangollen	Mid schists
Holopella, monilis, M'Coy	Llanfyllin, Meifod, and Glyn Ceiriog	Mid limestone
,, tenuicincta, M'Coy	Ditto	Ditto
Raphistoma	Glyn Ceiriog, Llanfyllin	Mid and upper limestone

CEPHALOPODA.

Bellerophon bilobatus, Sow.	Deirw, Glyn Ceiriog, Llanwddyn	Lowest limestone and uppermost beds
,, carinatus, Sow.	Dolydd Ceiriog	Lowest limestone and schists
,, dilatatus, Sow.	Glyn Ceiriog	Ditto and mid limestone
,, expansus, Sow.	Ditto	Lowest limestone
,, ornatus	Glyn Deirw, Glyn Ceiriog	Ditto
,, sub decussatus, M'C.	Llanrwst, Meifod	Upper schists
Orthoceras politum, M'Coy	Llechwyd, Nant Iorweth, Glyn Ceiriog	Mid limestone
,, sub undulatum, Port.	Llanwrst	Uppermost schists
,, vagans, Salt.	Bala	Lower to uppermost beds
,, ventricosum, Sharp.	Corwen, Bala	Mid schists
,, annulatum, Sow.	Dermyddfawr	Uncertain
Phragmoceras arcuatum, Sow.	Das Eithen	Mid limestone
Lituites cornu-arietis, Sow.	Glyn Ceiriog	Mid limestone to uppermost schists
,, anguiformis, Salt.	Fronfrys, Glyn Ceiriog	Upper limestone

ON THE PTEROPODA.

By Frederick P. Marrat.

ON A FOOTPRINT PROBABLY OF THE IGUANODON, IN THE FREE PUBLIC MUSEUM OF LIVERPOOL.

By Thomas J. Moore, Curator.

In the collection of fossils purchased for this Museum in 1858 from Mr. E. Charlesworth was a valuable series of remains of the Iguanodon, and a large footprint, all from the collection of the late Dr. Mantell. The footprint was stated to be that of an Iguanodon, and to be of considerable interest, but beyond this no information was received, nor was there any label attached to it.*

The specimen very closely resembles in general outline the "Natural cast of footprint from the Cliff, west of Hastings," figured by Mr. Beckles, in the "Quarterly Journal of the Geological Society," vol. x, pl. 19, but is more pointed in the heel. The outline is more vague than the "Natural imprint of the foot of an Iguanodon," figured by Mr. Tylor, in the same journal, (vol. xviii, p. 248,) inasmuch as the pressure and form of the several phalanges is not indicated, neither is there any trace of claws. But these and other similar footprints and tracks figured in the Journal are prints and tracks on the surface of the rock itself, whereas the specimen under consideration is a separate and distinct cast, free from any rock surface whatever. It closely resembles a coarse model of the foot of some three-toed animal of large size. One surface is somewhat

* Such of the Iguandon bones as were labelled with a locality were from the Isle of Wight.

flat, with the toes and heel nearly on the same plane. The other surface is rounded. Neither affords any evidence of the texture of the sole, or of the nature of the covering of the upper part of the foot, nor is there any distinct indication of junction with the leg. Indeed it is difficult to determine by which surface the sole of the foot is represented, or how a model of the entire foot, extending as far as the leg, could have been formed.

If the flat surface represents the sole, then it must have been a very flat foot which made the impression, the so-called heel-mark being on the same level as the tips of the toes, and the probability of the cast being that of an entire foot is considerably increased. If the rounded surface be the under side, then the cast is doubtless nothing more than that of a *very* deep impression made on the yielding soil. In this case a rather high-heeled creature would be indicated.

Each side toe is divided from the central one by a deep well-defined cleft; the middle toe is much the longest, and the side toes diverge from it at nearly equal angles. Each toe is somewhat pointed. The mass is composed of fine sand, very closely compacted, and of a pale brown colour.

The dimensions are as follows:

From heel to tip of middle toe	17	inches.
" " " of each outer toe	14	"
" " to either cleft	10	"
Greatest breadth	14	"
Height	9	"

The persevering search of Mr. Beckles for remains of the creatures which made the trifid footmarks he had so frequently met with in the Wealden, resulted in his discovery of the bones of a foot determined by Professor Owen to be that of a young Iguanodon. This interesting specimen is figured of the natural size (20 inches in length) in his *Monograph of the Fossil Reptilia of the Wealden*, part

iv, pl. 1, published by the Palæontographical Society, for 1857, and it conclusively proves the Iguanodon to have had but three toes, at least on one pair of feet.

If the cast now exhibited was found in a locality from which Dr. Mantell had obtained undoubted Iguandon remains, the inference would be fair that this also might be of Iguanodon origin. Such an inference receives strength from the evidence referred to above, that the Iguanodon had three-toed feet; and, while it must be borne in mind that the *Hylæosaurus* was also three-toed, yet it was of more slender proportions, and the original belief (coming as it probably did from Mantell himself, who doubtless had due reason for entertaining it) that the cast was that of an Iguanodon, may continue to be received as probably its correct designation.

ON THE HOT WINDS OF AUSTRALIA.

By George S. Worthy.

A Field Meeting was held at Storeton, on Friday, the 17th instant.

MARCH 14th, 1865.

The President, HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S., in the Chair.

In consequence of the Council having invited the presence of ladies, there was a larger attendance than usual. Mr. Potter exhibited several beautifully preserved

fishes from the chalk of Lewes, forming a small portion of his rich collection of Cretaceous fossils.

The following communications were read:

DESCRIPTION OF PART OF THE LOWER JAW OF A LARGE MAMMAL, PROBABLY OF DEINOTHERIAN TYPE, FROM PERIM ISLAND, GULF OF CAMBAY, INDIA.

By Henry Duckworth, F.G.S., F.L.S.

This specimen was discovered by the author on the shore of Perim Island, at low water, and on his return to England was submitted to the late Dr. Falconer, who pronounced it to be of great interest, and made the following elaborate report upon it:

The sandstones and conglomerates of Perim, it may be observed preliminarily, are of Miocene age.

This specimen consists of a mutilated portion of the right ramus of the lower jaw, comprising the fang portions of one or more molar teeth, together with about two inches of the entire and sharp edge of the diasteme. The internal alveolar wall is broken off and polished by rolling, and the crowns of the teeth are also entirely wanting.

The specimen is truncated in front through the diasteme, and behind in a line with what is inferred to be the second molar. The surface of the bone has acquired a vitreous polish, and is covered here and there with white undetermined incrustations.

The fragment is chiefly remarkable for the compressed character of the ramus, and for the great concave curve of the lower margin in front, which is deflected downwards in a bold curve, intermediate between that of *Deinotherium Indicum* and *Mastodon (Trilophodon) Angustidens*.

The compression of the ramus is too great for an adult jaw of *Deinotherium*, and the downward deflection greater than is met with in any species of Mastodon. The anterior end of the fragment is curved slightly inwards, to meet the corresponding opposite side, but no portion of the symphysis remains.

Regarded from the anterior end the section shows a deep compressed elliptical core, considerably in advance of the mentary foramen, and which, therefore, cannot be regarded as the dentary canal, but rather the alveolus of a very large and solitary recurved incisor, as in *Deinotherium Giganteum*, or deflected, as in *Mastodon Angustidens* The mentary foramen is situated posteriorly to the anterior fangs, and at about two-thirds of the vertical height of the outer surface of the jaw.

Part of the outer layers of the bone has recently been denuded from the external surface.

The mentary foramen is of no great size. The diastemal edge is raised and very sharp, and follows an outward direction, where the anterior part of the ramus commences to be bent inwards.

Unfortunately, all evidence derivable from the crowns of the teeth as regards the degree of composition and complexity is entirely wanting.

The principal dimensions are as follows:

	Inches.
1. Extreme length of the fragment taken at the inferior margin (as a chord to the arc)	7.75
2. Versed sine of the concavearc of the lower jaw, when rested upon the ends of the fragment.	0 8
3. Vertical height of ditto at anterior termination of the diasteme	5
4. Vertical height of the jaw, in a line with the anterior molar........................	5 1
5. Greatest thickness of the jaw behind........	2 8

	Inches.	
6. Greatest thickness in a line with the mentary foramen	2	2
7. Length of the remains of the diasteme	2	2
8. Vertical height of the supposed alveolus of the incisor	3	2
9. Transverse ditto	1	5

As an approximative opinion, Dr. Falconer was inclined to regard the specimen as a portion of the lower jaw of an animal of Deinotherian form, and it might be of a young "*Deinotherium Indicum*," but the contour of the lower jaw in that species is so imperfectly known that nothing more positive can be asserted regarding it.

ON THE ORIGIN OF GRANITE.

By George H. Morton, F.G.S.

Only a part of this communication was read, the remainder will be brought forward during the next session, and the Abstract will probably appear in the Proceedings for 1865-6.

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ABSTRACT

OF THE

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SESSION THE SEVENTH,

1865–66.

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1866.

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HUGH F. HALL, F.G.S.
CHARLES POTTER.

ABSTRACT OF THE PROCEEDINGS

OF THE

Liverpool Geological Society.

SESSION SEVENTH.

OCTOBER 10TH, 1865.

THE PRESIDENT, HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S., in the Chair.

WILLIAM FERGUSON, F.G.S., F.L.S., was elected an Ordinary Member.

The following communications were read:

ON A WOODEN IMPLEMENT FOUND IN BIDSTON MOSS.*

BY CHARLES RICKETTS, M.D.

WHEN the works were in progress, about eighteen years ago, for the purpose of diverting the course of the River Birket, in order that Wallasey Pool might be converted into the Birkenhead Dock, there was found, at a depth of fourteen feet from the surface, and amongst the roots of the trees which were exposed in making the cutting, a

* This paper caused considerable discussion, and several members expressed their disapproval of the opinions expressed in it.

wooden implement, consisting of two flattened pieces of wood, respectively 8 inches and 6½ inches long, and 3 inches broad, which appeared to have been fashioned into shape by an exceedingly blunt instrument, both being partially charred upon one side and along one edge; when placed together they fit pretty closely in apposition, excepting at one end, leaving a cavity, the more exposed part of which is charred. The use to which it had been applied was, probably, as a means of kindling a fire, in the same manner as is common amongst the North American Indians and the natives of Australia, by placing an ignited brand in contact with touchwood, wrapping both together in grass, inserting it into the cavity, and blowing upon it until it bursts into a flame. As these pieces of wood were found at a depth of 16 feet or 18 feet below high water mark, it follows that there must have been a subsidence of the land to this extent, and somewhat more, since the time they had been fashioned by man, and the rudeness with which they have been cut into shape would lead one to infer that it must have dated from a period prior to the Roman invasion.

Having alluded to the frequency of the occurrence of subsidence when a considerable amount of deposit has occurred at the mouths of large rivers, Dr. R. considered that the amount of *débris* brought down by the numerous rivers emptying themselves into the Bay of Liverpool would be insufficient to cause, by its weight, the great depression which has occurred in this neighbourhood, but that the same effect might probably be induced by the tendency which there is in the Atlantic waves to carry forward and deposit in this bay (being an area of between 3,000 and 4,000 square miles) the materials which are the result of the disintegration of the coast lines of Ireland, the West of England, and the South of Scotland.

NOTES UPON A RECENT EARTHQUAKE NEAR ULVERSTONE.

By R. A. Eskrigge, F.G.S.

This communication was based chiefly upon an article published in the *Ulverstone Advertiser*, by Mr. John Bolton, F.G.S.

The earthquake took place on February 18th, 1865, and is remarkable because, although the shock was exceedingly violent, its effects were felt only over a very small area, estimated by Mr. Bolton at not more than seven square miles. The district affected occupies the southern part of the Barrow and Rampside promontory, at the northwest corner of Morecambe Bay. The line of most intense action appears to have been along the coast from Conkle, in a northwesterly direction, to Westfield Point, and thence on to Rampside. Along this line the earth was in some places fissured, especially near Conkle, and a considerable number of springs burst forth, estimated at over 300, which continued to run for several hours. It is not known with certainty whether these springs were hot or cold, nor whether the water was fresh or salt, but Mr. Bolton considers most probably the former.

Mr. Bolton was at Barrow at the time, and thus describes his personal experience: "The earthquake was felt at Barrow with very different degrees of intensity in different parts of the town. That portion of it farthest from the harbour, and which is on comparatively high ground, was only slightly affected, but the strand and other streets in the lower part of the town were affected with considerable violence. Of this I had personal experience, having been nearly thrown from my chair whilst writing, and had I been standing at the time it is likely I should have been thrown down. The shock, or rather movement, of the

earth did not cease instantly, but seemed to continue for four or five seconds, as I had time to turn towards the window, and I could see, by noticing other buildings near, that there evidently was considerable movement amongst them; and a very few seconds after it was over there occurred a scene of a very ludicrous character, although an earthquake is no laughing matter. There is in our neighbourhood a sailmaker's large workroom, in the top story of a large block of buildings, and the earthquake had only subsided a few seconds when I saw the men rush out like bees, swarming and almost tumbling over each other to escape from the buildings. They believed the whole block was coming down, as the timbers in the roof had been in such violent commotion. The men could not believe the shock was caused by an earthquake, and they were a considerable time before they again ventured to ascend to their workroom."

Nine days after the occurrence Mr. Bolton walked over the district to observe the effects and to collect reliable information. At Roosecote, about one mile inland, several chimney stacks were injured and were being repaired. At Moorhead a cottage chimney was completely thrown down, part of it falling inside, so that the inmates had a very narrow escape. The walls of every room were cracked, and even some of the flags of the floor broken by the shock. A cottager, who was working in his garden at the time, said he felt himself "ru-roo'd about as if he were in a riddle, so that he could hardly stand." In Rampside nearly every building was more or less injured, except the parsonage, the church, and one or two other houses on high ground. Several houses were so much shaken as to require shoring up with timber, and will have to be taken down. "But the most remarkable case was that of a house close to high water mark, on the shore of Morecambe Bay. This house

is built of red sandstone, dressed, bedded, and jointed, but since its erection the front wall of the house has been whitewashed several times, which had almost entirely hidden the jointing, but the earthquake has not only made several large cracks in different parts, but almost every stone in the front wall now shows a clear joint broken through the coats of whitewash; thus proving that nearly every individual stone had been moved on its bed by the shock. This house, as well as several others, must be taken down immediately."

The following is the account given by William Simpson, whom Mr. Bolton vouches for as respectable and creditable. "John Thompson and I were coming from Fowler Island, one mile from Rampside, and when we had got nearly half way we saw, at a distance from us, a great mass of sand, water, and stone thrown up into the air higher than a man's head. It was nearly in a straight line between us and Rampside, and when we got to the place there were two or three holes in the sand, large enough to bury a horse and cart, and in several places near them the sands were so soft and puddly that they would have mired any one who had gone on to them. We thought this very strange, but supposed it was owing to the frost, *for we did not feel the least shock nor know anything of an earthquake until we got to Rampside and saw that everybody was in terror and the houses sadly shattered.* We then went to Conkle, and found a crack in the ground at the foot of the railway embankment, about thirty yards in length, and water was boiling up in a great many places, just like the great spring at Bien Well. ("Bien Well" a copious spring of very pure water, on the sea shore, five miles north of Rampside.) There were more than 500 of them, and they extended half a mile on towards Barrow, and at one place there were a great many in a straight line and only two or three yards from each other." Mr. Bolton says, in returning to Barrow

he followed the line pointed out by Simpson, which is N.W. and S.E., and saw the remains of these springs, but no water was flowing from them.

The most remarkable fact in the above account is, that these men felt no shock, though only 200 yards in a S.E. direction from what appears to have been the chief seat of disturbance, and from this and his own experience Mr. Bolton concludes the earthquake shock travelled from S.E. to N.W.

After summarising the phenomena, Mr. Bolton remarks that the facts as above recorded, and especially the extreme violence of the shock in connection with the limited area affected, prove that the seat of disturbance was not far below the surface, and are in opposition to all the theories propounded to account for earthquakes, and especially that of Professor Rogers, now largely accepted by geologists.

The author of the paper agreed with Mr. Bolton that the cause of the disturbance could not be very deep seated, and suggested that possibly the shock might have arisen from the sudden falling in of an extensive cavern in the mountain limestone, which occurs in the northern part of the Barrow promontory, and is probably continuous under the Upper Permian rocks of the locality affected, and that the water was forced up to the surface by the sudden disturbance either along an old line of fault or a new fissure. There is no noticeable change of level in the district, but a very small subsidence occurring suddenly might produce the phenomena without affecting the apparent level of the country.

As a parallel, in some degree, to the smallness of the area affected, the author referred to the case of the parish of Comrie, in Scotland, which is more frequently visited with earthquakes than any other spot in Great Britain. And as a parallel to the outburst of springs attending an

earthquake shock in a region far from any volcano, to the remarkable phenomena which occurred at New Madrid, in the State of Missouri, in the year 1811, as described by Sir C. Lyell in his Elements, page 466. This latter is, perhaps, although on a larger scale, the most completely analagous case on record to that of the earthquake at Barrow.

NOVEMBER 14TH, 1865.

THE PRESIDENT, HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S., in the Chair.

JAMES L. LOBLEY and EDWARD NIXON were elected Ordinary Members.

The PRESIDENT delivered his opening address.

GENTLEMEN,

We meet on the present occasion to inaugurate formally the Seventh Session of the Liverpool Geological Society.

Allow me to express a hope that our deliberations this year may be attended with pleasure and profit to us all.

It affords me much gratification to announce to you that the Society numbers at present nine Honorary Members and fifty-eight Ordinary Members. Since the commencement of the session three members have resigned or ceased to be connected with the Society, but, as the same number of new names has been added to our list, the foregoing figures will not be affected.

During the past year we have lost by death, I regret to say, one of our Ordinary Members, Mr. Thomas Urquhart, whose quiet, unassuming and genial bearing endeared him to all who had the pleasure of his acquaintance or friendship. He was one of the first to join the Society, and ever took a warm interest in its work.

The proceedings of the Society during the past session were of a very satisfactory character, and I am happy to find that our published Abstract has been very favourably noticed by one of the leading scientific journals of the day.

At the same time, I cannot forbear expressing my regret that we have not had greater variety in the names of the contributors. I do hope that many who have not already done so, may be induced to come forward this session with communications, for it is only in this way that real and lasting interest in our Society and its work can be kept up.

Among the more important contributions to our proceedings I must enumerate Mr. Charlton Hall's communication on "The changes that have taken place in the coast of North Wales, between the River Dee and the island of Anglesea." A paper upon "The geology of the country in the vicinity of Builth," by Mr. Eskrigge, with a list of fossils, collected by the author during a visit to that locality, will be found of great service to any who may be desirous of becoming practically acquainted with the geology of that attractive district.

Mr. Davis, of Oswestry, again favours us with one of those tabulated lists of fossils, which are so valuable to the geological student. This time he has selected the "Bala Limestone and its associated beds in North Wales" as the groundwork of his labours.

The communication, as I have before said, is in a tabular form, and in the three columns into which the lists are divided we have, *first*, the names of the fossils; *secondly*, their particular locality; and, *thirdly*, the strata in which they occur.

But the proceedings of the Society being in the hands of all the members, I do not think you will expect me to enter into any detailed examination of their contents.

The remaining communications I will, therefore, do little more than refer to by name.

Our indefatigable Honorary Secretary has favoured us with papers upon "The Records of Geological Time," Reports upon the Society's Field Meetings at Llangollen and Bidston, and a memoir "*On the Origin of Granite*," a subject which, I am glad to find, is to be taken up again on a future occasion,—I hope this session,—and I trust that we shall then have both communications in extenso in our next volume.

Mr. Worthy has read two papers before the Society; one upon "The Sections along the course of the Avon at Clifton," and the other upon "The Hot Winds of Australia."

Mr. Hugh Hall read an able paper on the "Geology of the North Coast of Antrim."

Mr. Moore communicated an interesting description of a footprint, supposed to be that of an *Iguanodon*, in the geological collection of our local Free Public Museum.

Mr. Marratt's paper on the "Pteropoda" was valuable, as suggesting inquiries as to the analogies and relations between existing and extinct forms of that interesting group of molluscs.

The only remaining communication was one which I had the honour of reading before the Society, upon "A portion of the lower jaw of a supposed young Deinotherium, from Perim Island, in India."

The fields in which geological investigation is being conducted are now so extensive and various that I cannot do more on the present occasion than advert to some of those more striking and important discoveries that have recently been occupying the attention of geologists.

And first, then, I must allude to that deeply interesting discovery in Canada, which has so completely revolutionized all generally received views respecting the commencement of life upon this earth.

It has been ascertained, I think I may say beyond a doubt, that those formations which immediately underlie the Silurian and Cambrian deposits, and which are termed Metamorphic, on account of their altered condition, instead of belonging to a period in the world's history when as yet Life had not charmed away dark melancholy chaos, or, to express my meaning in a single word, instead of being, as they were generally supposed to be, ***Azoic***, afford unmistakeable traces of organic life.

It is true that Sir Charles Lyell long held that although, from the peculiar character of these rocks, no traces of organic life might be detected in them, it by no means followed that they may not have existed before the formations in question were subjected to those metamorphic influences to which they owe their present condition. The deposits in which this deeply interesting fact has been brought to light are the so-called Laurentian Rocks, whose equivalents are to be found in the northwest of Scotland. The distinct character of these latter was made out by Sir Roderick Murchison in 1858, when he applied to them the name of Fundamental Gneiss. Their identity with the Canadian rocks was determined three years later.

The Laurentian formation in Canada has been subdivided into two groups, the Upper and Lower, the thickness of the former amounting to 12,000 feet, and of the latter to 18,000 feet, making the enormous total of 30,000 feet! Zones, or bands of Limestone, of great thickness, occur in both, and at least three of these bands have been ascertained to belong to the lower group.

It had been suspected for some time past that organic remains existed in these rocks, and the suspicion was at length confirmed by Sir William Logan, whose communications on the subject to the British Association at Bath, and, subsequently, to the Geological Society of London, have deservedly attracted so much attention in the scientific world. Nothing could be more satisfactory than the manner in which the discovery was worked out. Sir William Logan's paper was accompanied by communications from Dr. Dawson and Dr. Carpenter and Mr. Sterry Hunt, upon their structure and mineralogical characters respectively.

The localities where the fossiliferous beds principally occur are the Grand Calumet, on the River Ottawa, and at Grenville and Burgess, though it has not been determined yet what relation the strata at Burgess and Grand Calumet bear to those at Grenville, or to one another.*

It was at first supposed that these organic remains were corals, but on subsequent careful examination by Dr. Dawson they proved to be Foraminiferous in character, growing in large sessile patches, like Carpenteria and Polytrema, but of much larger dimensions.† Its distinctive characters are—

1st. *General form.*—Massive, in large sessile patches, or irregular cylinders, growing at the surface, by the addition of successive laminæ.

2nd. *Internal structure.*—Chambers, large, flattened, irregular, with numerous rounded extensions, and separated by walls of variable thickness, which are penetrated by

* Sir W. Logan's communication to the Geological Society, in Quarterly Journal, vol. xxi, p. 49.

† Sir W. Logan's communication to the Geological Society, in Quarterly Journal, vol. xxi, p. 49.

septal orifices, irregularly disposed. Thicker parts of the walls with bundles of fine branching tubuli.*

From specimens of the "Eozoon," in the Museum of the Canadian Survey, it would appear to have grown in large patches, which, in course of time, united, and formed great masses, penetrated by deep irregular canals,—to have assumed, in short, the appearance of a coral reef.†

The suggestive synonym of "Eozoon" has been applied to this interesting fossil, and the specific title of "Canadense" to the particular form described by Dr. Dawson. This most important discovery has, as I have already observed, completely overturned all previously existing notions as to the commencement of *life* upon this world.

Enormous as was the vista already opened out to us, how infinitely prolonged has it become now!

The Eozoon is stated to have been recently discovered by Mr. Sandford, in Ireland, in the green marble of Connemara, in a quarry in the Binabola Mountains.

Mr. Rupert Jones, who has examined the specimens, reports that he has found in them all the characteristic features described by Dr. Carpenter and Dr. Dawson, and it may, therefore, be regarded as identical with the Canadian fossil.

Hitherto the boundary line between the *Permian* and *Triassic* formations has been extremely hazy and unsatisfactory, and any attempt to define the limits of each group must be gratefully acknowledged by geologists. In this spirit, therefore, we receive the important communications upon this subject by Sir Roderick Murchison and Professor Harkness.

* Dawson. Quarterly Journal Geological Society, vol. xxi, p. 54.

† Dawson. Quarterly Journal Geological Society, vol. xxi, p. 53.

Careful examination of the Red Sandstone of the northwest of England, which have hitherto been regarded as of Triassic age, proves them to be the natural upper limit of the Permian and Palæozoic deposits.

It is only fair to state that Professor Sedgwick had long ago pointed out in the western region at St. Bee's Head and in Furness the existence of the equivalents of the Magnesian Limestone, but without referring the beds to the Permian group.

Thus the Permian system now assumes a three-fold division in England, viz., the upper and lower beds, with an intermediate limestone, or its fossiliferous equivalent.

One of the most anomalous and puzzling members of the Triassic group has until quite recently been the formation known on the Continent as the St. Cassian beds. According to all geologists who have studied their position and stratigraphical relations, they lie above the *Muschelkalk*, but their fossils belong to genera otherwise *Palæozoic*, whereas those in the underlying deposit are of Mesozoic type. A more careful examination of the deposit, however, has materially altered the views of foreign geologists upon the subject.

Dr. Gustav Laube having undertaken the investigation of the whole of the St. Cassian Fauna, we may expect to see the question placed ere long in a more satisfactory position. The first part of his work has already appeared, and we find in it a description of the Sponges, Corals, Crinoids, and Echinoderms, comprising altogether 115 species, of which 83, or nearly 30 per cent., are new. Many of the species belong to genera which have not hitherto been found in rocks below the Jurassic, so that if the remainder of the fauna should prove of the same character there will be few difficulties to explain.

One very important result is that the Encrinite, hitherto supposed to be identical with the well known Lily Encrinite of the Muschelkalk, differs considerably from it, and is a new and very distinct species.

The question of the true relations of the "Avicula Contorta" beds has latterly been exciting much attention, especially upon the Continent, where that formation is more fully developed than in this country. These beds, which are intermediate between the Lias and new Red Sandstone, possess many puzzling and anomalous features, the great difficulty being to decide to which of the adjacent formations they present the greatest affinity.

In our own country they have indeed been definitely placed at the head of the Keuper, or upper division of the new Red Sandstone, under the name of the Penarth Beds; and they are identical with those white limestones in Somersetshire, described, in 1861, by Mr. Charles Moore, as the *Rhætic* beds, from the extensive development of similar deposits in the Rhætian Alps.

They are also identical with the Kœssen beds in Germany; with the Gervillia beds; the passage beds of the Lower Lias; the Infra-Lias (bars;) and the Täbingen beds. Lately several important memoirs have been published on the Continent, in which this question is discussed at great length, but the opinions expressed in them are about as various as the writers themselves, for, while Herr Waagen calls the Zone of the Avicula Contorta the uppermost member of the Keuper, M. Deslongchamps and M. Renevier consider it to belong to the Lias, the former positively, the latter more diffidently. Then, again, Herr Von Seebach appears undecided, Mr. Boyd Dawkins calls it the passage beds of the Lower Lias, and Herr Von Dittman treats of it as a separate formation, but, at the same time, thinks that if it must be classed with either of

the adjacent formations, it ought to be placed with the Keuper. Generally speaking, it may be said that the French and Italian geologists consider the Avicula Contorta Zone to belong to the Lias, whilst the German and English either treat it as a separate formation, or class it with the Trias.

A little pamphlet has recently been published at Toulouse, by the Abbé Sanno Solaro, in which is recorded the discovery of a number of remains of Deinotherium at Escanecrabe, in the department of the Haute Garonne. Among them was an enormous pelvis, quarried out of a soft marly sand, belonging to the Miocene period, under the direction of the Abbé, and which measured six feet across the crest of the iliac base, was nearly perfect, and evidently belonged to a full-grown Deinotherium. Careful examination of this bone has led Monsieur Solaro to the somewhat startling conclusion that the Deinotherium, after being in turn a Cetacean and Amphibious Pachyderm, was a huge Marsupial Pachyderm, somewhat resembling the Nototherium, only of very much larger dimensions.

Although they have not as yet excited much attention, few discoveries, I think, are more interesting than those lately made at Pikermi, in Attica.

The classic soil of Greece, it would appear, teems with wonders of nature as well as of art, and the Palæontologist has been as amply rewarded in his own particular field as the archæologist.

An exhaustive work on the subject, by Mons. Gaudry, is now in course of publication, and the first part of it will be devoted to a description of the fossil fauna, which comprises several species and genera of the Quadrumana, Carnivora, Rodentia, Pachydermata, Ruminantia, Edentata, Birds and Reptiles, many of which approach very nearly

to those of Africa and India, and they are regarded as identical with those which are generally considered characteristic of the Miocene division of the Tertiary epoch.

So far there have been brought to light and described a new species of Mastodon, one of the Deinotherium, three of Rhinoceros, two of Palæotherium type, viz., Acrotherium and Leptodon Græcus, a species of Sus and Camelopardalis Atticus, one species of Quadrumana, ten species of Carnivora, one of the Rodentia, and one of the Edentata.

A report upon the fossil contents of the Genista Cave at Gibraltar has been presented this year to the Geological Society of London. The explorations, as, perhaps, many of you are aware, were latterly conducted by Mr. Busk and the late Dr. Falconer, and previously by Captain Brome, the Governor of the Military Prison. The following particulars will, perhaps, help to convey to you some idea of the extraordinary richness of this new field. The results, I should observe, are further interesting from their differing materially from those obtained in most of the bone caves that have been explored in the south of Europe.

The rock of Gibraltar, as is well known, abounds in caves, and these are of two classes:—1st, Seaboard caves, at various heights above the level of the sea, and horizontally excavated in the ancient cliffs by the waves; 2nd, Inland caves, descending from the surface, and in connexion with great vertical fissures, by which the mass of the rock has been rent at remote epochs, during disturbances caused by violent acts of upheavement, like the well known cavern of St. Michael. The Genista Cave belongs to the second class; it forms a great perpendicular fissure, which, by the vigorous measures adopted by Capt. Brome, has either been excavated or traced downwards to the depth of upwards of 200 feet below the level of the plateau of Windmill-hill. It was full of fossil remains of quadrupeds and

birds, of the former of which some are now wholly extinct, others extinct in Europe and repelled to distant regions of the African continent, others either now living on the rocks or in the adjoining Spanish peninsula.

The following is a list of the species so far identified:

Pachydermata.
Rhinoceros Etruscus. Extinct.
„ leptorhinus. „
Equus. Young animals only; species undetermined.
Sus priscus. Extinct.
„ scrofa. Living.

Ruminantia.
Cervus Elephas. One barbarus.
„ dama.
Bos. A large form, resembling the Aurochs in size. Remains few and imperfect; species undetermined.
Bos taurus. Remains abundant in upper chamber.
Capra hircus.
Capra Agoceros. Two forms of this animal, which is the Ibex; found in immense quantities throughout the fissure.

Rodentia.
Lepus timidus. Rare.
Lepus cuniculus. Very abundant.
Mus rattus.

Carnivora.
Felis leopardus.
„ pardina.
„ serval.
Hyæna brunnea. Now repelled in the living state to Southern Africa.
Canis vulpes.
Ursus. Species undetermined, but not the ordinary cavern bear—spelæus.

Delphinidæ.
Phocæna communis.

Birds. Remains numerous and species undetermined.
Tortoise. Rare. Species undetermined.
Fish. Remains numerous in upper chamber.

The rock of Gibraltar, it may be observed, is now bared of natural forest trees and destitute of wild animals, with the exception of the hare, rabbit, fox, badger, and a few magot monkeys, probably the descendants of introduced animals.

The most important feature in the case is, perhaps, the character of the extinct Fauna of Gibraltar, compared with that of England, Germany, and France, as far south as

the shores of the Mediterranean and the Pyrenees. Of the prevailing forms in the latter countries, such as the *Mammoth*, Rhinoceros tichorinus, Ursus spelæus, Hyæna spelæa, not a vestige has been detected among the fossil remains of Gibraltar.

In the latter the Carnivora are the most significant. The three species of Felis are of African affinities; the Hyæna brunnea, now for the first time ascertained to have existed in Europe, is at the present day chiefly found near the Cape of Good Hope and Natal. That any of these animals could have crossed the Straits is manifestly impossible. The obvious inference, therefore, is one which independently suggests itself to us whenever we look at the map of the old world, that at some period or other, most probably not a very remote one, the two continents were connected. Sicily has, latterly, afforded almost incontestable evidence of the same kind.

A further most interesting fact has also to be noticed in connexion with this cave., viz., the discovery of human remains in the upper chambers. They appear to have belonged to thirty or forty individuals. They were accompanied by stone implements, of the polished stone period, broken quivers, a large quantity of pottery, marine shells, of edible species, and various other objects.

No way of access from the surface, by which these materials could have been introduced, has been discovered, but on carefully examining the ground Messrs. Busk and Falconer believed that it will be found under the southern wall of the prison enclosure. They have, therefore, recommended the authorities to grant permission to Capt. Brome to explore from that side, a request which would, no doubt, be at once acceded to.

The human bones are of high interest, in consequence of certain peculiar characters which many of them present.

They appear to belong to widely different epochs, although none of them, perhaps, are of very high antiquity, *i.e.*, before the historical period. That the upper chambers were ever inhabited by savage men the explorers consider highly improbable, and lean to the idea that they may have been used as places of deposit for the dead. To my mind it appears as if they had been used as places of refuge from some desolating catastrophe, most probably diluvial. And here I cannot but remark upon the significance of the numerous discoveries of a similar character with the above that have been made of late years in various parts of Europe, *all* presenting, more or less, the same features, pointing thereby, as I think, to their having been brought about by one vast and uniform cause.

Evidence of the probable contemporaneity of man with some of those huge pachyderms and other animals now extinct in Europe seems to accumulate, but it must be confessed that it is not always of a very satisfactory or convincing kind. I do not know in what light you will regard the following addition to it, but certainly the fact to which it relates is, under any circumstances, very singular and interesting. It is related in the "Geological Magazine" of last month:—On 21st August last Mr. Milne Edwards coummunicated to the Academy of Sciences of France a letter from M. Lartet, on the discovery, in the ossiferous deposits of La Madeleine, of fragments of a plate of ivory, upon the surface of which rude lines of the figure of some animal had been cut. The late Dr. Falconer, who was present with Messieurs Christy and Lartet when the drawing was found, at once recognised the head to be that of an elephant, and, from a number of lines on the neck, that it was intended to represent an elephant with a long mane, in fact, the *Mammoth*. And then the account goes on to say, and, perhaps, wisely so, that as a

figure of this interesting relic has not yet been published, it would, perhaps, be unsafe to pronounce upon its authenticity, but we have the favourable opinion of Messrs. Milne Edwards, Quatrefages, Desnoyers, besides the discoverers, as also that of Mr. Franks, the President of the Society of Antiquaries. Perhaps the strongest point in favour of the genuineness of this primeval sketch is the circumstance that numerous carvings on bone and horn, accurately representing the reindeer, musk, ox, horse, &c., have been found in these same caverns of the Dordogne, otherwise it would be most unwise to rest upon what may after all really be but an extraordinary coincidence. There is this satisfactory inference, at any rate, to be derived from this and kindred discoveries, that races which were capable of executing such advanced works of art—I use the term, of course, in a relative sense—could not be the miserable, degraded, and unthinking savages that certain philosophers in our days believe and teach.

Foremost among the various geological publications of the past year must be noticed the new and sixth edition of Sir Charles Lyell's "Elements of Geology," that indispensable text book for every student of the science. Much new matter, as may be supposed, has been added to the original work, many parts of which have been re-cast.

The greatest additions of new matter are to be found in the chapters upon the Tertiary formations, a department of the science which Sir Charles has made peculiarly his own.

The "Geological Magazine" continues to sustain its excellent character, all the numbers during the past year having contained very valuable original articles by some of our most distinguished geologists and palæontologists, as well as reviews and notices of all the newest British and foreign publications connected with the science. Most of

the papers are written in a popular style, such as must render them interesting to the general reader, whilst others, of a more severe character, will recommend themselves to the advanced student. This little magazine, then, supplies a want which, I think, is met by no other journal of the kind, and all interested in the progress of geological science will do well to support it.

The proceedings of the Palæontographical Society continue of unabated value and interest. The last volume contains monographs, by Dr. Wright, on the fossil Echinodermata of the Cretaceous formations in Britain; by Mr. Salter on British Trilobites; by Mr. Davidson on the Devonian Brachiopoda, in continuation of his great work on that extensive group of molluscs; by Mr. Searles Wood on the Bivalves of the Eocene; and by Professor Owen on the fossil reptilia of the Cretaceous formations.

The "Quarterly Journal of Science" has now completed two years of its existence, and it is satisfactory to find that it is taking up that high position which its promoters have from the first been endeavouring to place it in. The notices of proceedings of the various geological societies throughout the country, and its reviews of new works on the science are particularly worthy of study, and are especially valuable to those who have not leisure to investigate for themselves or to read through recondite treatises.

Geological science, and, indeed, that of natural history generally, has sustained a heavy loss during the present year in the death of that most distinguished man, Dr. Hugh Falconer. Born at Forres, in the north of Scotland, and educated at Aberdeen and Edinburgh, he proceeded at an early age to India, as Assistant-Surgeon in the Bengal Establishment. At Saharunpore, near the Himalaya Mountains, where he was stationed for some time, he

was associated with the eminent botanist, Dr. Royle, and there it was that he commenced, in conjunction with Sir Proby Cautley, those explorations of the Sivalik Hills, upon the magnificent issue of which his fame will mainly rest. The new forms of Mammalian life, by his labours, were so numerous and remarkable, that his discoveries form quite an era in the history of the science.

It is greatly to be regretted that his great work, "Fauna Antiqua Sivalensis," in which it was intended to describe and illustrate the whole of the fossil Fauna of the Sivalik Hills, has never been completed. The plates of nine parts were brought out in 1844-7, but the letterpress was much in arrear, and owing to Dr. Falconer's return to India about that time its publication was never resumed. It is to be hoped, though, that memoranda are in existence from which sufficient materials may be gathered for the completion of this most important work.

In 1848 Dr. Falconer was appointed superintendent of the Botanical Gardens at Calcutta and Professor of Botany in the Medical College. In 1850 he visited the Tenasserim provinces to examine the teak forests, and subsequently lent much valuable aid to the introduction of the Cinchona plant into India. In the early part of 1855 failing health compelled him to retire from the service, and he returned to England. But though enfeebled in body his mind was active as ever, and it was not long before he commenced his famous treatise on "The Species of Mastodon and Elephant occurring in the Fossil State in England;" but this work, like the great Indian one, was destined never to be completed, no more than the first part having as yet been published.

The great interest which Dr. Falconer took in the exploration of bone caverns and in the fluviatile deposits in the north of France is well known, and it was mainly owing to

his influence and powerful advocacy that the exploration of so many new fields was entered upon both in this country and upon the Continent.

Having had the honour and pleasure of Dr. Falconer's acquaintance, I cannot forbear to add my humble testimony to the greatness and goodness of his character. On my return from India I had occasion to submit to him for his inspection a collection of fossils—principally Mammalian remains of the same age as those found in the Sivalik Hills —and never shall I forget the patient care with which he examined them and determined their nature.

I cannot but allude here to the further loss we have sustained by the death of that hardworking palæontologist, Dr. S. P. Woodward, assistant curator in the department of geology and mineralogy in the British Museum, and the author of that well known and most useful manual of recent and fossil shells, as also of many original memoirs on conchological and geological subjects. These memoirs exhibit the vast acquaintance of the author with natural history in general, and of his talent in determining the relations of obscure organisms.

Both ethnology and geology have been deprived, during the past year, of one of their choicest ornaments. I allude to Mr. Henry Christy, whose name has latterly been much before the scientific world in connection with that of the eminent French palæontologist, Mons. Lartet.

During the last years Mr. Christy devoted much time and labour to the exploration of the caves in the Vezère Valley, in Dordogne, France, and to a collection of the curious relics of primeval times in the history of our race which they have furnished.

Blessed with ample means, Mr. Christy was enabled to carry on this work in the fullest and most satisfactory manner, and it is owing to his thoughtful liberality that so

many museums and institutions, both in this country and on the Continent, possess such characteristic collections and specimens of the contents of those wonderful caverns.

Mr. Christy's services to the State at the time of the Irish famine will long be remembered. Whilst he may only be known to a few as a keen and eminent ethnologist and geologist, he will be known to all as a lover of his countrymen and a benefactor to mankind in general.

The geological survey of the United Kingdom has been proceeding steadily and satisfactorily during the past twelve months. It had long been felt desirable by all geologists that the relations between the Palæozoic rocks of Cumberland and Westmoreland and those of Wales should be ascertained with accuracy, and it is satisfactory to find that their examination is now being proceeded with. Some of the results have already been made public, and among other things we learn from Professor Harkness that the Skiddaw slates—the oldest rocks in Cumberland—are by no means so ancient as was generally supposed, but are simply of Lower Llandeilo date, as is proved by the Graptolites, Orthidæ, and Lower Silurian fossils which they contain.

Exploring in ascending order from the Silurian base of the lake region, and working eastwards, the surveyors will next have to develop the structure of the great mineral fields of Durham and Northumberland.

The surveyors have also been lately engaged in the districts east of London, near the estuary of the Thames, also in the counties of Northampton and Cambridge and in the West Riding of Yorkshire. In Scotland they have been at work upon the Lowlands of Ayrshire and Fifeshire, but none of the results having as yet been published, I am unable to give you any further particulars.

And now, gentlemen, I must draw my remarks to a close. I feel I have touched very imperfectly indeed upon the several topics I desired to bring before you, but, as I observed at the outset, the area in which geological science is now cultivated is so extensive and varied that I could not hope to do more. Allow me to express my sincere hope that our proceedings this session may be full of interest and profit to us all, and whilst we are engaged in these fascinating studies let us never regard the wonders which our science reveals to us without remembering the Almighty Creator whose greatness and goodness they are all the silent witnesses of.

The following communication was then read:

ON THE POSITION OF THE WELLS FOR THE SUPPLY OF WATER IN THE NEIGHBOURHOOD.

By G. H. Morton, F.G.S.

The introductory portion of the paper referred to the conditions under which water exists in the rocks beneath the surface; the reason why some formations contain a much larger quantity than others; and the triassic strata—to which the rocks around Liverpool belong—present an unusual abundance of pure water. The author described, by means of diagrams, the way in which water sinks through the porous strata, accumulates so as to form great subterranean reservoirs, flowing into the ocean above the tidal range, and explained the means employed to raise it to the surface, and continued as follows:

"Whatever opinion may be entertained regarding the great porosity of the triassic strata, and their universally containing large quantities of water, the intimate connec-

tion of the faults and subdivisions of the rocks must of necessity always have an important bearing on any attempt to obtain it by artificial means. Sections through the strata, showing the position of the wells, indicate how far these petrological conditions have been studied, while the quantity of water ultimately obtained must tend to show the value of such considerations in selecting the site of any future well. To the geologist, the examination of the respective sections, with the position of the various public wells indicated thereon, is interesting without any application to the water supply of the district, but the subject is now of general interest, in consequence of the late scarcity of water caused by the remarkably dry Autumn. From data in my possession it appears that the well at Green-lane was the last that was sunk, (1845-6,) and that it was completed eight years before the geological survey of the district, and several years before Mr. Edward Hull, F.G.S., had described the succession of the triassic rocks of Cheshire. In 1845 the order of the stratification in this district was unknown, the occurrence of the most important faults unsuspected, and the supposed position of the beds so confused, that beyond the mere dip of the strata, and the contour of the surface, there was nothing to guide the engineer in selecting a proper site for a well. The whole of the strata around Liverpool was considered to be the Bunter sandstone, and it was said to consist of three subdivisions—the lower red, the middle yellow, and the upper red—and the district was said to be broken up by a network of fractures and dislocation at right angles to each other. Later investigations, principally by Mr. Hull, proved the opinions then held to be very incorrect. If we consult the geological maps of the Government Geological Survey, and several sections published by myself more recently, we find that, instead of the whole of the sandstone in the neighbourhood belonging to

the Bunter, a part belongs to the Keuper formation, and that the yellow sandstones of the latter constitute a higher portion of the series than the red-beds of the Bunter, instead of being a central band or subdivision. I mention this great error so particularly because it led directly to another —ignorance of every important fault in the district, that was bounded by the trias on both sides. A regular succession of the strata was supposed to occur where there was nothing of the kind, and there appeared no reason to suspect that great dislocations traversed the district from north to south. Under these circumstances it was by mere chance if a well was sunk in a proper site, although no blame can be attached now to individuals who, no doubt, did their best under the circumstances."

The author then exhibited sections of the strata at Green-lane, Windsor, and Bootle, and described the general dip of the strata as being towards the east, with great faults at intervals of a mile or two. The Green-lane well was indicated upon a section as being a little to the west of one of these great faults, with the strata dipping to the fault, and cropping out to the west, in which direction and considerably to the north and south there are no other faults for some distance. Several reasons were given to prove that this well was in the best possible situation, and the yield is 3,000,000 gallons daily, almost equal to that of all the other wells put together, which confirms the conclusions drawn regarding its site. The sections of the strata in which the Windsor and Bootle wells occur, show those wells to be differently placed: they are situated on the eastern sides of faults with the strata dipping to the east, and as the Bootle well is nearer the fault than the Windsor well the quantity of water obtained is less. The site of the wells in the town does not seem to have been selected according to any definite rule. Mr. Morton quoted the opinion of Mr.

Cunningham and Mr. Hull with regard to the passage of water through faults, and stated his own opinion to be that, though water would find its way through them, they certainly presented a great hindrance to its doing so, and he stated that the site of a well should generally be at the downthrow side of a fault, when the inclination of the strata is towards it, and concluded by saying, "I consider that the Green-lane well is the only one belonging to the Corporation that is in a proper situation; that the supply of water might be largely increased by sinking from one to three additional wells; and that the neighbourhood of Childwall or Woolton would be a desirable locality for one of them."

DECEMBER 12TH, 1865.

SAMUEL B. JACKSON, Esq., in the Chair.

Mr. ESKRIGGE exhibited two specimens (head and tail) of a Lichas, recently found by him in the Llandeilo flags, near the town of Llandeilo. Mr. E. stated that so far as he was aware, this was the first time the occurrence of this genus in rocks below the Caradoc had been noted. This species has since been figured and described under the name of Lichas Patriarchus, by Mr. H. Wyatt Edgell, in the Geological Magazine, vol. 3, p. 160.

The following communication was read:

ON GRANITE AND OTHER METAMORPHIC ROCKS.

BY GEORGE H. MORTON, F.G.S.

THE author favoured the igneous origin of Granite, but considered it to have been subsequently altered by metamorphic action. With regard to the occurrence of

stratified Granite and Gneiss, as at Malvern, St. David's, &c., he stated that a sandstone, containing the necessary elements,—Silica, Alumina, Magnesia, Lime, Potash, &c.,—would, in certain cases, form a rock exactly resembling the crystalline strata referred to. Schistose rocks are no doubt altered shales and slates, and they consequently retained the original laminæ of the rock. Sandstone, being coarser, formed Gneiss, and if it did not possess any lamination, it is improbable that metamorphism would cause foliation of the new minerals, and, consequently, a rock like Granite would result; but it would be a bedded rock, and of aqueous origin. The author showed specimens of sandstones that possess little or no lamination, and considered that such kinds accounted for the origin of the beds of Granite or Syenite, which, under such conditions, should be called Gneiss; and referred to Professor Jukes's statement that Granite and Gneiss cannot be always identified by hand specimens, observation in the field being necessary.

JANUARY 9TH, 1866.

THE PRESIDENT, HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S., in the Chair.

THOMAS GARDINER was elected an Ordinary Member.

The following communications were read:

NOTICE OF SUBMERGED FORESTS AT RHOS, NEAR COLWYN.

By H. F. HALL, F.G.S.

IN examining the district referred to in Mr. Charlton R. Hall's paper on the "Ancient Coast Line of North Wales" (Proceedings for 1864-5, page 7) I was fortunate

enough to notice on the shore opposite the village of Rhos the remains of two ancient forest beds, the appearance of which I shall briefly describe. To understand their relation, however, to the neighbouring geological formations, I must detail shortly their position. Rhos is an ancient manor-house and village, lying in the bottom of the valley between the Little Ormeshead and Colwyn Head, both which are Mountain Limestone cliffs, at present sea washed. Of this formation are the hills lying behind the long narrow valley stretching between the two heads, which enclose gently sloping mounds of boulder clay, which rests against Colwyn Head on the land side, and runs in low cliffs along the shore, thinning out till it reaches Rhos, where it is seen on the shore only, the land at Rhos being very low for about 200 yards, where a marshy valley runs inland towards Conway, between two hills of boulder clay, one of which, on its seaward side, again rises in low cliffs, running towards the Little Orme from Rhos until Abergonol, which Mr. C. R. Hall supposes to have been the ancient main outlet of the Conway, is reached. Here the land becomes so low for about three-quarters of a mile as to have necessitated the building of a sea wall, beyond which the boulder clay again rises to a considerable height, in cliffs resting against the more ancient sea cliffs of the Little Orme, which, by their caves, at a height of 150 feet, show an elevation since the boulder clay was deposited of at least that extent. The boulder clay deposits are of great interest in themselves, containing many huge specimens of grooved, polished, and striated blocks and pebbles, but a consideration of them is foreign to the present subject. The valleys at Rhos and Abergonol, which run into one another, are clearly the result of the scooping out of the boulder clay deposit, which covers the whole district, by the action of water.

The forest beds lie on the shore, immediately in front of the low valley above mentioned at Rhos, and are of the same extent, viz., about 200 yards in length, corresponding with the width of valley. They are to be seen only for about two hours before and two hours after high water. The upper bed lies about six feet below high water mark, and the lower about twelve feet below the same datum. The two beds are, therefore, about six feet apart, and are separated by a bed of blue clay, containing pebbles, though sparsely. The upper bed is exposed the whole distance from Rhos Fynach, a very ancient residence, to Lord Combermere's cottage in the village. It consists of a bed of peat and tree roots, at present about one foot thick, overlying about two feet of blue clay. The peat has evidently been much denuded, and no doubt many of the trees have been washed away, the hollows where they have lain being distinctly seen. On the surface, and through the whole of the peat, lie many branches and trunks of trees, lying in every direction as they have fallen. There are also about a dozen stumps, with roots attached, still remaining in situ, the roots penetrating into the clay below. I traced one trunk for fully fifty feet in a straight line, when it was lost in the water-worn edge of the mass. One trunk in situ has a diameter of three feet where the roots spring, and another I found with roots as thick as a man's leg, before they were broken off, extending in every direction from the trunk for about six feet. It is, therefore, evident that the trees must have been of a much greater size than those now growing in the neighbourhood, which are poor and stunted. The bark is attached to most of the trees, both stems and roots.

The lower bed is exactly similar to the one just described, except that in it there are more upright trunks in situ, and fewer lying horizontally. The red clay of the

shore runs into the blue clay above which the peat has accumulated, and I attribute the blue colour of that below the peat to discoloration by decaying vegetable matter.

The fact that the beds are coincident in extent with the valley behind led me to suppose that there might possibly be some evidence in it as to them, and on inquiry I ascertained that in sinking a well behind a new hotel now in course of erection, at the very mouth of the valley, the following interesting section had been obtained:

Sandy Gravel............	3	feet.
Solid blue Clay	15	,,
Peat bed, with trees, about	1	foot.
Blue Clay .... ,,	4	feet.
Peat bed, with trees.. ,,	1	foot.
Fine Clay, mixed with sand	3	feet.
	27	feet in all,

when a bed of pebbles was reached, and water obtained. We have thus evidence of the existence of these forest beds in the valley named. I obtained specimens both of the peat and trees from the rubbish still lying at the mouth of the well, which, although nearly full of water, had not then been completed. The denudation of the gravel and clay from the shore would just bring the forest beds to a corresponding level with those found in sinking the well. That this denudation is being at present very rapidly carried on is evidenced by several facts, of which Mr. J. Parry Evans, of Rhos Fynach, informed me. Within his memory—say forty years—at least thirty yards had been taken from his fields, and are now covered by the sea. During the fifteen years in which he has had possession of the estate he has had to make three new roads to his house, in consequence of the old ones being washed away. The posts of the old entrance gates now stand within the tidal

limits. He is the possessor of a fishing weir, granted to his ancestors by Queen Elizabeth, (the deed of grant, signed by the celebrated Earl of Leicester, being in his possession,) which weir, before that, was held by the monks of Rhos Abbey, the ruins of which the sea now breaks over *outside* his present weir, and, consequently, these ruins are covered even at low water. I was unable to gather any evidence as to whether the abbey was in existence in Elizabeth's reign, but supposing it to have been above high water mark in the time of Henry VIII, we would have evidence of a depression of at least twenty feet in about 300 years. In addition to the ancient manor-house of Rhos Fynach, there is an interesting antiquarian relic in a field close to the sea shore, a small chapel, nearly perfect, about ten feet by six feet, built of stone boulders, and roofed with an arch of the same materials, the only cut stones being the windows, which externally are mere slits, and the corners of the external walls. A fragment of an oaken beam, supporting the wall above the east window, is still to be seen, but it crumbles to the touch. The chapel contains a fine fresh water spring, and tradition states that St. Trillo, the patron saint of the parish, used there to bless the fishery.

Through the valley behind Rhos, before which we have seen the forest beds lie, runs a small and now nameless stream, (hardly more than a ditch,) a few feet wide, draining the valley and also a great part of the longer valley of Abergonol, which runs to Conway. This ditch is the line of division between the counties of Denbigh and Carnarvon; the latter county, on this side the present river Conway, being a mere strip of shore land, terminating in the peninsula of Crevddyn and the Ormeshead. It seems to me difficult to suppose that so small a stream would have been chosen as the line of division, or that so

small a part of the County of Carnarvon would have been left west of the stream, had the division taken place at a time when the present configuration of the country obtained. But it would by no means have been an improbable division, if we suppose, as there seems to me every reason to believe, that a large district of land stretched seaward, that is, northward and westward of the present coast line, and that the present dividing ditch assumed the conditions of an outlet of the Conway, with a width of 200 yards.

This supposition would quite coincide with the facts that in a valley extending an unknown distance seaward, between two undulations of boulder clay, (portions of which still exist,) and with a depth beyond that at present existing of twenty to twenty-five feet, a forest, protected by the high land on each side, existed; which, during a period of depression, became subject to the overflow of the fresh waters of the Conway, destroying its vegetable life, and covering it with silt and mud, partly derived from the boulder clay which formed its banks. A subsequent oscillation, which need not have been more than a few feet, again withdrew the waters and clothed the fertile soil with verdure, another forest of great trees filling the valley; which again, under another depression, has been destroyed by the Conway once more filling its old channels, and accumulating a mass of mud, fifteen feet in thickness, above the most recent peat bed. The sandy gravel, containing undoubted marine shells, I attribute to the action of wind and sea, driving up the present beach over the surface of marsh just at the entrance of the valley. It may be that a more recent elevation has taken place, which has turned the Conway to its present course, or it may be that the breaking through of the Conway to its present channel has turned away its waters, and left dry the beds of its

ancient outlets. But whether the one or the other be accepted as the explanation of a sheet of water 200 yards in width having become a pasture ground, the fact remains that the last change we see, viz., the depression now taking place on this coast, is exposing to the light the remains of trees and herbage that have been covered by an accumulation of fifteen feet of river mud, and which the name of the place, "Rhos Fynach," the "Marsh of the Monks," shows was very much in its present condition as long ago, at any rate, as the reign of Henry VIII.

As an additional item in the evidence already adduced as to the former course of the Conway, I may mention that tradition still points out Dinarth, a place a mile inland, situated on a knoll overlooking the valley running from Conway to Abergonol and Rhos, as once a landing place for discharging vessels.

The trees, I think, will be found to be oak and pine. I found no animal remains, but mine being only a casual visit, it is very possible that such remains as the bones and horns of deer, &c., may still be obtained on further search.

ON THE GEOLOGY OF THE COUNTRY BORDERING THE MERSEY AND DEE.

By George H. Morton, F.G.S.

There is often a difficulty in defining the boundaries of a Natural History or Geological district, where a clear physical outline cannot be determined upon. In forming local collections of natural objects a radius of five or ten miles is generally adopted, though seldom strictly regarded when a rare or an interesting species occurs beyond the prescribed

distance. In my "Geology of the Country around Liverpool,"* the sea coast and the River Dee formed the western and southern boundary lines, while the outcrop and nearest development of the Coal Measures on the east terminated the district in that direction. On the north no precise line was necessary, and no place beyond Ormskirk was referred to. Though there are few districts that present such interesting petrological conditions as those which occur within this limited area, the uniformity of the scenery, and the paucity of fossils in the strata, render it desirable to extend it so as to include a contiguous tract of country embracing additional attractions, where older rocks rise up in bold mountain masses, and contain abundant relics of the organisms of long past ages of the earth's history. By including a part of Flintshire, from the Dee to the rise of the Silurian rocks a few miles beyond the Vale of Clwyd, a district is included possessing the highest geological interest, with every possible variety of outline, from bare rugged cliffs to level river valleys, containing deep alluvial deposits supporting a rank vegetation. A circle, within a radius of twenty miles from Hilbre Island, at the Cheshire side of the Dee, includes Abergele, St. Asaph, Denbigh, Mold, Hawarden, Chester, Prescot, and Ormskirk. The whole of the area is of easy access, and opens a wide and instructive field for the geological student, with a number of formations rarely to be found in such close proximity. Considering the great series of formations included, it cannot be thought too comprehensive, for though half the area is occupied by water, the upper part of the Silurian strata, a trace of the old Red Sandstone, the whole of the Carboniferous rocks, some Permian beds, an entire development of the Trias, besides Bone Caves, Glacial marks on rocks and Drift deposits, old Land

* Published by the Liverpool Naturalists Field Club, 1863.

Surfaces with silt beds, and sand accumulations, are presented within a very confined geographical area.

The following is a general synopsis of the geological formations within the circumference of the area described—radius twenty miles from Hilbre Island—

1 DRIFT SAND and ALLUVIAL DEPOSITS.	10 PEBBLE BEDS.
2 OLD LAND SURFACES, SUBMARINE FORESTS, and SILT BEDS.	11 LOWER SOFT RED and VARIEGATED SANDSTONE.
3 UPPER DRIFT SAND.	12 PERMIAN.
4 BOULDER CLAY.	13 UPPER COAL MEASURES.
5 LOWER DRIFT SAND.	14 MIDDLE OR PRODUCTIVE COAL MEASURES.
6 CAVE DEPOSITS.	15 LOWER COAL MEASURES OR GANNISTER SERIES.
7 RED MARL.	16 MILLSTONE GRIT.
8 KEUPER SANDSTONE.	17 MOUNTAIN LIMESTONE.
9 UPPER SOFT RED and VARIEGATED SANDSTONE.	18 OLD RED SANDSTONE.
	19 WENLOCK SHALE.

These formations vary considerably in importance and thickness, but each of them represents a distinct interval of time during which it was deposited. It is now merely intended to give an outline of the geology of the district, to furnish the groundwork for future illustration, and indicate the direction in which those who are so disposed can assist in extending our knowledge of the stratification of our immediate neighbourhood.

The lowest stratum, the Wenlock Shale—Upper Silurian—can be examined in many places on both sides of the Vale of Clwyd, especially where it crops out from under the Mountain Limestone on the banks of the Elwy, four miles west of St. Asaph, which is the most convenient centre to work from. The strata consists of dark shaly beds, containing a profusion of the usual Wenlock fossils. *Atrypa reticularis, Orthoceras primævum, Cardiola interrupta,* and the stems of Encrinites, may be collected in abundance. In other localities, where the fossils are rarer, the occasional

specimens of Orthoceras and Cardiola remind the geologist of the slate quarries of Llangollen, which are worked in strata of the same age and are similar in appearance.

Above the Silurian a thin representative of the old Red Sandstone occurs, and is succeeded by the Mountain Limestone, the most conspicuous formation in the district. It presents the bold ridge to the S.W. of St. Asaph, and appears to be about 400 feet thick, the upper beds having been denuded. Fossils are rare in the limestone, which is of a light gray and white colour. The dip is usually about 20 degrees N.E., and the formation is unconformable to the underlying rocks. All the Mountain Limestone in the neighbourhood of St. Asaph and Abergele belongs to the lower part or base of the Carboniferous Series. In the direction of Holywell it has been entirely denuded, excepting at Tremeirchion, Bodfari, Llangwyfan, and some other places, leaving the Wenlock Shale exposed over a considerable tract. At the town of Caerwys it occurs again, dips N.E., and is succeeded by the upper part of the formation, which is well exposed in a number of quarries above Holywell, where it gradually assumes a cherty aspect, and passes upwards into the Millstone Grit. The upper beds of the limestone are usually of a dark colour—often black, from the presence of bitumen—and are crowded with the following characteristic Carboniferous fossils, all of which are very common—

Aviculopecten, sp., Pinna, sp., Productus giganteus, Spirifer pinguis, Productus semireticulatus, Productus latissimus, Syringopora geniculata, Lithostrotion striatum.

In the deep works of one of the mines near Holywell, the lower white limestone is reached at the depth of about 400 feet, and a large quantity has been brought to the surface, but fossils are very seldom observed, confirming the paucity of organic remains in the lower half of the deposit.

The Millstone Grit reposes conformably upon the Mountain Limestone, and is succeeded by the Coal Measures, which are worked along the margin of the Dee. The principal seam is the main coal, supposed to represent the Wigan nine-feet; but there is no bed known so low as the Arley Mine of Lancashire. Beneath the sands of the Dee the coal strata are probably faulted against the Triassic rocks, but the line of the dislocation is only partially known.

The Permian strata, which are absent in the immediate neighbourhood of Liverpool and in Wirral, occur in the Vale of Clwyd, though not coloured on the map of the Geological Survey. The strata, consisting of red and bluish shales and marls, occur at Pentre Celyn, near Ruthin, also about Llangynhafal, a few miles to the north, and other places. Impressions of plants have been found in these beds.

The Triassic rocks of the Vale of Clwyd are supposed to represent the lower part of the Bunter formation, but they are so deeply covered by the Boulder clay that sections can seldom be seen. Where the base of the Trias or Permian is visible, it rests directly upon the denuded surface of the Wenlock shale or Mountain Limestone, so that the absence of the Coal Measures in the vale forms a strong contrast to the country on the east of the Mersey.

Under the Triassic rocks, from Huyton to the shores of the Dee, geologists entertain no doubt of the existence of the Coal Measures, and that time and necessity alone are required to confirm the opinion. But in the Vale of Clwyd the Coal Measures—if ever deposited there—were removed by denuding agency before the Permian and Trias were deposited. These are important considerations bearing on the quantity of coal to be obtained by deep borings through

the Trias, a subject engaging much attention at the present time, connected as it is with any calculation that can be made regarding the amount of coal available to mining industry.

Next in importance, or rather in interest, in the country being described, are the caverns in the limestone rocks of Abergele and St. Asaph, and they deserve a more minute examination than they have yet received. Dr. Buckland certainly examined the caves, but never described them, though in his "Reliquiæ Diluvianæ" he mentions, on the anthority of Pennant, the tusk and two molar teeth of the elephant as having been found at Halkin in Flintshire.

The caverns appear to have been old subterranean water courses, through which stones and other *débris* were carried at a time when there was higher land in the neighbourhood, and when the physical character of the locality was entirely different to what it is at the present time. The passage of water gradually widened the original fissures in the limestone, and formed long and lofty channels, which were choked up and filled with sediment, embedding stones and frequently the bones and teeth of mammalia. The caverns were probably finally filled at the commencement of the Glacial period, though human remains seem to have been introduced at a later period. It was certainly before the beautiful valley of the Elwy was hollowed out by the action of denuding agency, when the whole contour of the ground was different, and when the elephant, the rhinoceros, the bear, and the hyena constituted a portion of our local Fauna.

FEBRUARY 13TH, 1866.

R. A. ESKRIGGE, F.G.S., in the Chair.

The following communications were read:

ON THE GEOLOGY OF SUSSEX.

By Charles Potter.

The author (who formerly resided at Lewes) gave a description of the Wealden, Cretaceous, and more recent strata of the Forest-ridge and the surrounding country, including the coast. He alluded to the extensive iron-works which once existed in the district, and illustrated his communication by many choice specimens from his collection.

ON A NEW LOCALITY FOR PARADOXIDES DAVIDIS AND ASSOCIATED FOSSILS IN NORTH WALES.

By R. A. Eskrigge, F.G.S.

In introducing the subject, the author referred to the discovery by Mr. Selwyn, more than twenty years back, of a fragment of a large trilobite, apparently identical with the Swedish species, *Paradoxides Forchhammeri.* But as it could never be satisfactorily determined where this specimen was found, its scientific interest was much lessened, if not entirely lost, so that it long remained merely as a challenge to the zeal and activity of geologists, and it was

not until 1863 that a true British locality was discovered for the genus. The merit of this discovery is due to the distinguished palæontologist, Mr. Salter, who, perhaps more than any other, deserved such an honour, and, though partly the result of accident, it was also in great measure owing to that scientific acumen and insight which have so often led their possessor into the path of success. The place where it was found is the now celebrated Porth-y-Rhaw, near St. David's, in Pembrokeshire, whence the species has been named, *Paradoxides Davidis*, and where, owing to the assiduous and able researches of Mr. Hicks and Mr. Salter, so rich a fauna has since been brought to light, (see Geological Magazine, vol. 3, p. 27.)

Within two years another locality for *Paradoxides* was accidentally found by Mr. Readwin, of Manchester, at the gold mines on the river Mawddach, near Dolgelly, a district subsequently well worked by Mr. Williamson; but neither of these is the place from which Mr. Selwyn's original specimens can have come, for the species are quite distinct.

This latter locality is on the eastern flank of the great Merioneth anticlinal, and the relation of the beds in which the fossils are found to the underlying Cambrian is identical in North and South Wales, so that, from his general knowledge of the country, Mr. Salter felt convinced that by a patient search on the other or northwestern side of the Cambrian axis, near the point where the grits dip under the overlying more slaty beds, the same fossils would be found. He accordingly wrote to Mr. Homfray, of Portmadoc, pointing out the spot, marked Tafarn-helig on the map, as the most likely, and requesting him to institute a careful examination. After two days' work, Mr. Homfray vindicated most satisfactorily the correctness of Mr. Salter's induction, by finding, at the exact spot he had indicated,

seven or eight of the characteristic St. David's fossils, *but not Paradoxides.*

During a recent run through North Wales, the author of this paper paid a hasty visit to the spot, and, notwithstanding that he had to work in the bed of a stream, and in the midst of pouring rain, he had the good fortune to detect two distinct and unmistakeable fragments of the *Paradoxides Davidis,* one a pleural spine, and the other a portion of the glabella of a large individual. This discovery completes the parallel both with the South Wales beds and also with those near Dolgelly, though the number of species found in North Wales still falls far short of those known at Porth-y-Rhaw. The fossils found by the author at Tafarn-helig comprised *Agnostus princeps, Microdiscus punctatus, Conocoryphe variolaris, Conocor. sp., Holocephalina, Erinnys, Theca, Paradoxides Davidis,* and some fragments at present undetermined. Most, if not all, of these had, with the exception of *Paradoxides,* also previously been found by Mr. Homfray, but as yet the beds have only been very partially worked, and it may be confidently expected that many other forms will be found there.

In order to illustrate the position of the beds more clearly, and, at the same time, to attach a more general interest to the paper, the author gave a sketch of the main features of the geology of the central portion of North Wales, extending in a northwesterly direction to Snowdon and Llanberris, and east and south to the Arenigs and Cader Idris, *i.e.,* to the country on both sides the Barmouth and Harlech grits, which form the anticlinal axis before referred to. He also exhibited and explained three of the admirable horizontal sections of the Ordnance Survey, on the scale of six inches to the mile, which relate to this district.

MARCH 13TH, 1866.

THE PRESIDENT, HENRY DUCKWORTH, F.G.S., F.L.S., F.R.G.S., in the Chair.

Dr. RICKETTS exhibited a series of shells from the Lower Drift Sand and Boulder Clay. Mr. MOORE numerous bones of the Dodo, from the Mauritius, almost sufficient to make up a skeleton of that bird.

The following communications were then read:

ON THE CHARACTERS OF ROCKS.

BY F. P. MARRATT.

THE GEOLOGY OF THE NEIGHBOURHOOD OF ST. DAVID'S, PEMBROKESHIRE.

BY R. A. ESKRIGGE, F.G.S.

Owing to indisposition, the Author had been unable to write this paper, but at the request of the Society, the communication was delivered *vivâ voce.*

THE COAL FIELDS OF DENBIGHSHIRE AND FLINTSHIRE.

BY EDWARD NIXON, MINING ENGINEER.

The coal districts of these counties are very variable, as continuous upheavings of Mountain Limestone and Millstone Grit completely sever and change the dip and quality of the seams of coal. At Chester we have good opportunities of examining the New Red Sandstone, which no doubt covers a large and extensive field of coal, extending under

a great portion of Cheshire and Lancashire. I believe some of these coals to be almost within workable distance, and a time is not far distant when measures will be adopted to prove them. Going westward from Chester, in the villages of Broughton and Kinnerton, we have the lower Coal Measures, but without any workable seam. About two miles north of Kinnerton coal was worked, at the Rake Colliery, nearly 18 feet thick, but as the district is much disturbed by faults the colliery was abandoned.

From the Rake, near Hawarden, to the Queen's Ferry district many collieries exist, but as faults are also numerous and a great portion of the coal, being near the crop, having been worked for many years, not much is done there now. Along the Dee side from Queen's Ferry we find, near Connah's Quay, the rocks belonging to the Lower Coal Measures, which continue nearly to Flint, but the strata being so very variable that now and then a small colliery may be seen working an unknown coal a mile or two from the coast. At Flint, Bagilt, Mostyn, and nearly all along the Dee side, we have the Coal Measures workable, and at Mostyn we may trace the coal dipping under the sea and afterwards making its appearance on the Cheshire side near Parkgate.

From Kinnerton, passing westward towards Buckley, and about one mile east of Little Mountain Colliery, the greatest fault known in North Wales passes nearly north and south. This—the Millstone Grit fault—passes under Peny-monid Church, from thence under Caergwrle Castle and Bwlch gwin, near Minera, where it may be seen in all its splendour. This district, for romantic attraction and beauty, without taking into consideration its geological features, is not surpassed in North Wales. On one side of the chasm may be seen the Mountain Limestone, with its veins of lead, and immediately on the other side we see Millstone Grit and

shales, belonging to the Lower Coal Measure. The fault in question brings in, near Buckley, the Lower Coal Measures, but without any workable seam, until another fault running parallel, just on the boundary of the Little Mountain Colliery, supposed to be about 300 yards of a throw-up east, puts in all the coals known in the Buckley district.

Section taken at Little Mountain Colliery:

	YDS.	FT.	IN.
Strata	64	0	0
Bind coal	0	2	9
Strata	2	0	0
Hollin coal	2	2	0
Strata	24	0	0
Brassey coal	1	0	3
Strata	18	2	0
Rough coal	1	0	3
Strata	18	0	0
Main coal	3	2	0
Strata	60	0	0
Wall and bench coal, in two beds	1	1	6

All of the above coals are workable and of good quality, but in Buckley, as in many other places, the greatest portion of coals was worked many years ago. Old shafts and dirt hills throughout the whole village remind us of the toil in ages gone by.

Some forty years since some of the top seams at Little Mountain Colliery were worked, and the lower seams, including the main coal, abandoned, on account of the water being too abundant, machinery not being efficient to drain the shafts. At the present time we have effectually drained many acres of water from old workings, and have got a famous bed of main coal, 11 feet thick. This, with the exception of a little worked at Ewloe Hall and Buckley Collieries, is the only main coal in Buckley.

Buckley possesses many features of geological interest in addition to its coal and ironstone mines. It has been long famous for its manufactories in fire-clay ware. The clay is obtained from what is locally termed the fire-clay fault. This band of clay runs nearly in a north west position, and completely severs the Buckley coal field. Its formation not being definitely understood, many opinions have been held forth, and it is supposed by some to belong to the Permian age. Professor Beckett thinks it belongs to the Upper Coal Measures, but I have seen a similar bed of clay near Kinnerton, about three miles distant, immediately lying upon a hard silicious sandstone, which I am convinced belongs to the Lower Coal Measures. This clay sometimes attains a thickness of 40 yards, lying in layers of different qualities, and is extensively worked to great profit.

MOLD.

Leaving Buckley and proceeding towards Mold we find remains of early collieries, though the district is much upset by faults, all coals being in turn near the surface. No collieries are now working near Mold, except Broncoed, Bromfield Hall, and Wylva. The coals here are less in number, of a less thickness, and worse in quality than those found elsewhere. Immediately on the discovery of cannel coal in Leeswood, about five years ago, exertions were at once put forward to prove it also at Mold. Consequently several good shafts, with the best of machinery, were started at Bromfield Hall Colliery, and after spending a great deal of money and time cannel coal was proved to be nine inches thick only, too thin to be worked at any profit.

Under the present management a seam of coal about 20 yards above the cannel is now being worked, and considering the seam is only about three feet thick, a fair profit may be expected. The seams stand thus:

	YDS.	FT.	IN.
Bind coal	0	2	10
Hollin coal	2	1	6
Brassey coal	1	0	0
Main coal	2	0	0

Beyond Mold a range of Mountain Limestone hills run nearly in a N.W. direction, terminating at Holywell. The same range of hills passes Nerquis, S.E. of Mold, and cuts away all the Coal Measures westward. At Nerquis the measures are much shattered, main coal being found near the church at a considerable depth, whilst about half a mile up the valley, towards Leeswood, cannel coal of good quality is found in the hill side.

Leeswood I consider to be the richest coal field in North Wales. About six years since, all the main coal being nearly exhausted in the take of Mr. Henry Jones, a trial was made to prove the Lower Coal Measures, and at a depth of 95 yards below the main coal the famous oil producing cannel was found, much to the astonishment of all people in the neighbourhood.

Several faults running parallel to each other nearly north and south considerably cut up the district of Leeswood. Cannel coal was proved in the first instance over an up-throw fault, west, 90 yards, just on the crop of the main coal, but after it was proved sufficiently Mr. Henry Jones put down a large shaft on the east of this fault, and again proved the cannel at about 223 yards. The thickness of the cannel in this pit is greater than at any other in the neighbourhood. I measured it myself as being—

	YDS.	FT.	IN.
Shale	0	1	0
Smooth cannel	0	2	3
Curly ,,	0	1	6
Shale	0	1	0
	1	2	9

Over one thousand retorts are erected and in course of erection in the districts of Leeswood, Coed Talon, and Coppa Collieries, for the manufacture of oil from the cannel, showing at once the importance and wealth of the cannel found in the district of Leeswood. The present price of curly cannel at Leeswood Green Colliery is 28s. per ton, smooth cannel 9s. per ton, and the shale about 8s. 6d. per ton. In the manufacture of oils from these cannels we find curly cannel yields nearly 90 gallons, smooth 30 to 35 gallons, and shale about 35 gallons per ton. A lighter and better oil is obtained from the shale, but its yield being small, preference is given to the curly.

Section of sinkings at Leeswood Green Colliery:

	YDS.	FT.	IN.
Strata	54	0	0
Coal	1	1	6
Strata	15	0	9
Crank Coal	0	0	3
Strata	13	1	10
Brassey Coal	1	1	6
Strata	8	1	2
Coal	0	0	9
Strata	29	2	11
Main Coal	3	0	9
Strata	3	0	0
Coal	1	0	0
Strata	90	0	0
Cannel	1	2	9

Between the Leeswood and Brymbo Coal Fields is the great fault previously mentioned which completely divides these districts. The Brymbo Coal Field is the most extensive of any in North Wales, and collieries are most numerous, the produce from this district being very great, its coal being well known in Liverpool, and greatly

esteemed for its qualities as shipping coal. Immediately in the neighbourhood of Wrexham the Permian sets in, and, in order to develop the entire coal-field, it is necessary to go deeper for coals. At present shafts are in the course of sinking not far from Wrexham Station, and it is well understood that before main coal is reached they will have to go over 300 yards.

Section of one of the Byrmbo pits :

	YDS.	FT.	IN.
Strata	58	2	0
Powell or Bind Coal	1	1	0
Strata	10	1	0
Hollin or 2-yard Coal	1	2	0
Strata	6	2	0
Crank Coal	1	0	0
Strata	12	2	0
Brassey Coal	1	2	0
Strata	11	1	6
Black Bed Coal	0	1	6
Strata	23	2	9
Main Coal	2	1	6
Strata	19	1	9
Yard Coal	1	0	0

Throughout the whole district of North Wales the main coal always takes the preference. Its quality as a bituminous coal is well known; its thickness in different districts is variable, but on the whole the quality is about the same.

We cannot expect the main coal of North Wales to last many years, unless exertions are made to prove it under the Permian. The produce of coal from the United Kingdom for 1864 was nearly 93,000,000 tons, and out of this amount North Wales contributed 2,000,000. Drift lies near the surface over a great portion of Flintshire

and Denbighshire coal-fields, and in some instances large boulders of limestone, many tons in weight, form a portion of the drifted matter. In the valley from Mold towards Pontblyddyn and Caergwrle the drift in some instances attains a thickness of sixty yards, being very wet. Drifted matter again covers nearly all the Leeswood district, and up the valley, towards Nerquis, it was proved to be thirty-five yards thick, in the sinking of one of the Coed Talon Company's pits, which was very dry. In the parish of Hope large beds of drift were proved in the cutting of the Wrexham, Mold, and Connah's Quay Railway. Many very perfect fossils, chiefly belonging to the Mountain Limestone, are sometimes met with in these drift deposits.

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12, Castle-street.
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PALÆONTOGRAPHICAL SOCIETY,

INSTITUTED 1847.

This Society was established for the purpose of figuring and describing *the whole of the British fossils.* More than 3,000 species have already been described, and have been illustrated by upwards of 14,000 figures.

Each person subscribing one guinea is considered a member of the society, and is entitled to the volume issued for the year to which the subscription relates. The volumes, of which eighteen have been issued, consist generally of portions of from four to five monographs. All the back volumes are in stock, and can be obtained (one or more) on application to the Honorary Secretary, the Rev. THOMAS WILTSHIRE, Rectory, Bread Street Hill, London, E.C.

A list of monographs already published, as well as those in course of completion or preparation, can be also obtained from Mr. G. H. MORTON, Local Secretary for Liverpool, 7, London Road, Liverpool.

ABSTRACT

OF THE

PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

SESSION THE EIGHTH,

1866—67.

LIVERPOOL:
COURIER STEAM PRINTING WORKS, 44, CABLE STREET.
1867.

OFFICERS, 1866—67.

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CHARLES POTTER.
THOMAS J. MOORE, Cor. Mem. Z.S.

ABSTRACT OF THE PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

SESSION EIGHTH.

OCTOBER 16TH, 1866.

DR. RICKETTS, VICE-PRESIDENT, in the Chair,

ROBERT WESTWORTH was elected an Ordinary Member.

The following communications were read:—

ON THE OUTLIER OF CARBONIFEROUS LIMESTONE NEAR CORWEN, NORTH WALES.

BY CHARLES RICKETTS, M.D.

THIS small portion of Carboniferous Limestone, situated at least eight miles from the main band, was described in the Geological Magazine for June, 1865, by Mr. D. C. Davies, and its presence was, in a subsequent number, satisfactorily accounted for by Mr. Jukes, as being on the downthrow of the Great Bala and Yale fault, by which the Carboniferous Limestone has been brought down to the level of the base of the Wenlock shale. In neither of these papers was attention called to the great difference in the

direction of the dip of the beds, which in the most westerly quarry is 45° N.W.; whereas it changes about the middle to E.N.E., and opposite the farm (Hafod-y-calch) to S.E. There is also a great alteration in the angle of the dip, which is well seen in the middle quarry, where from 45° it varies as the strata dip towards the River Alwen to 15°. This variation originates at the site of a slickenside joint, and leads to the inference that this patch, being a fragment of the Carboniferous Limestone which once covered the whole district, has been preserved from destruction by being part of a synclinal curve, formed prior to the occurrence of the Great Bala fault, which Mr. Jukes has shown took place subsequent to the deposition of the Coal measures, and prior to the formation of the Trias. The other portion, which must at one time have covered the Wenlock shale on the opposite bank of the Alwen, has been removed by subaërial denudation.

ON THE CAVERNS IN THE TRIASSIC SANDSTONE AT NOTTINGHAM.

By Hugh F. Hall, F.G.S.

ON THE PRESENCE OF GLACIAL ICE IN THE VALLEY OF THE MERSEY, DURING THE POST-PLIOCENE PERIOD.

By George H. Morton, F.G.S., F.R.G.S.I.

In 1859, I described for the first time, to the Literary and Philosophical Society of Liverpool, evidences of the action of ice on the sandstone in this neighbourhood. To the south of Park Road, in the brickfields, where the boulder clay had been removed, and the surface of the underlying sandstone washed clean by the rain, the rock was found to

be perfectly smooth, but scored by numerous parallel grooves and striæ, which presented such a remarkable appearance as at once to indicate an origin from the passage of ice over the place. The discovery was an important one, for, except on the coast of Durham, no glaciation had been elsewhere noticed at such a slight elevation above the sea, and so far removed from any mountainous district.

In North Wales, the Lake District, and in Scotland such surfaces have been familiar to geologists for the last twenty-five years, and were in the first instance made known by Agassiz, followed by Buckland, and afterwards more minutely described by Ramsay and Hull. In all these districts glaciers seem to have radiated and descended from the central axes, and in their course scooped out and deepened the valleys, polishing and grooving the hardest rocks, so as to leave unmistakeable evidences of their powerful action. In the Vale of Llanberis the sides of the cliffs are worn smooth and furrowed, while in the ravines of Snowdon I have often seen the sun's light reflected from the glistering surface of the hard ice-polished rocks.

The Triassic sandstone in this neighbourhood is not susceptible of any polish, so that the heavy friction of the ice has only been able to make it flat, like the surface of a slab of stone worked smooth by a mason, and which is done by rubbing it with another stone and water. The effect produced is exactly similar in each case, except that the glaciated surfaces are grooved and striated with numerous straight lines, which have been produced by stones and pebbles embedded in the bottom of the ice. The most prominent grooves are nearly an inch wide, but generally narrower, and they often extend several yards in a clear and continuous line. An examination of their scored surfaces at once gives the idea that something possessing immense weight had been

dragged or pushed over them, and ice seems the only possible agent that could have produced such extraordinary impressions.

Having recently, in "The Geology of the Country around Liverpool," fully described the localities where these glaciated surfaces occur, it is needless to do more than briefly enumerate them. That first discovered and already referred to is in Toxteth Park, but I have since found it to be only part of a great area of glaciation, which seems to have extended over the whole of the rock, from the river considerably to the east of Park Road. The two localities at the north end of the town—west from Kirkdale—are also merely parts of a large area presenting the clearest evidence of ice having passed over it; and considering the extent of the areas at both the north and south ends of the town, there can be no doubt that they are continuous, though in consequence of the land being built over, there are seldom opportunities for observation. It is also important to remember, that a great deal of the rock is so soft as not to be able to retain any striation, and there are instances where the Upper Bunter must of necessity have been worn away by the ice which scored the Keuper sandstone close to it, although no indication is preserved upon the surface. An example of this kind is open for examination on the west of Stanley Road, Kirkdale.

The finest example of glaciation, and the most easily found, is in the brickfields on the east side of Park Road, north of North Hill Street, Liverpool.

The softness of the sandstone in this neighbourhood would not have preserved any striæ if it had been left exposed to the atmosphere, or with even a covering of vegetable soil, and consequently such striations never occur except where the rock has been *deeply* covered by the boulder clay. In every instance where the striated surfaces have

been preserved, it has been under a considerable thickness of the clay, and where they could never have been exposed since the glaciation was effected. The observations made at each of the localities establish two general results, viz.:— parallelism with the channel of the Mersey, and limitation to 120 feet above the sea.

There can be no doubt that all the scored surfaces originated at the same time, during the Post-Pliocene or Glacial period. When I made my early discoveries of these remarkable surfaces, I advocated the stranding of icebergs as the cause of the phenomena, but now, having found areas acres in extent, such a cause seems highly improbable, and some other and more efficient theory is necessary to account for the general glaciation that has taken place. The consideration of all the circumstances connected with these glaciated surfaces now leads to the conclusion that they were caused by a vast mass of ice flowing down the valley of the Mersey, and over the site of Liverpool. No striated surfaces have been found higher than 120 feet above the mean level of the sea. Of course the great mass of the ice would be below that elevation in the present river channel, but there must have been a considerable thickness above that height, to have been able by its weight to have ground and smoothed the surface of the rocks, and it is remarkable that the strata from 120 to 160 feet above the sea are usually, if not altogether, bare and uncovered by drift, and therefore could not be expected to have retained glaciation. That the elevation of about 160 feet was the upper limit of ice is rendered probable, for the most careful searching over a number of years has failed to detect any trace of a glaciated surface on the high land above that height, though the rock is usually protected by boulder clay, and presents every necessary condition for preserving it just as it was when first covered by the clay.

The sandstone beneath the bed of the Mersey is lower than in any other parallel valley in Wirral, or in the south of Lancashire, it was so before the deposition of the boulder clay, and being the deepest area of drainage, was the natural outlet, not only for water, but for ice from the country to the west, including the wide river valley.

In Cheshire, similar appearances are presented, though not so well exposed as those on the eastern side of the Mersey.

A little southeast of Bidston Hill is the remarkable eminence known as Flaybrick Hill. Extensive excavations for its building stone, carried on for many years, have almost entirely removed it, but in its natural state (twenty years ago), it presented a steep escarpment at the north, and has often attracted attention from its abrupt form, and the unusual direction of its steep sides.* Indications of glaciation are visible on the escarpment of this hill, and it presents just the appearance that the passage of ice would produce in its progress to the northwest, the direction indicated by the striæ on the side of the hill, a quarter of a mile to the southeast. The depth of the rock which is covered by alluvial land over Bidston Moss, with the high land of Wallasey between it and the mouth of the Mersey, where the striæ run nearly north, indicates that the glacier divided over the site of Birkenhead, one part proceeding northwards; and the other in a westerly direction.

It may appear a bold assertion to state that the country around Liverpool was once covered with ice and snow, and that the valley of the Mersey was the bed of a glacier, but in order to reconcile the mind to the probability of such having been the case, we have only to reflect on the condition of the contiguous lands at that time. During the Glacial period it is now considered that Scotland was

* Proc. Literary and Philosophical Society, vol. i, 1845, page 96.

covered with ice, that mighty glaciers flowed down from the higher land into the sea, and formed icebergs, and that the debris that now covers the country is the waste of its glaciated surface. The hills of Cumberland, Westmoreland, and North Wales had their summits covered with ice and snow, and great glaciers descended into the valleys on their flanks. At that time this part of England must have been very much colder than at present, and as probably the land was more elevated above the sea than now, it is very likely that ice may have formed and have been unable to melt at the low temperature that prevailed.

From the examination of the glaciated surfaces, and of all the circumstances connected with them, I consider that the existence and passage of a great bed of ice down the valley of the Mersey is the only theory that will satisfactorily explain the phenomena. Several geological conclusions bear upon this interesting subject; but one of the most important is the total absence of that comprehensive extinct pre-glacial fauna which occurs in North Wales—at Cefn Caves, within twenty-four miles from the Mersey. About Liverpool the country seems to have been completely denuded of pre-glacial drift, partly glaciated, and finally deeply covered with boulder clay, containing boulders almost entirely foreign to the neighbourhood, many of them being scratched, and all having probably dropped from melting icebergs, during a period of subsidence which followed that of elevation and glaciation.

Although at a greater elevation than 120 feet no evidences of the existence of ice have been found, there is a possibility of their having been removed from off the highest land by the denuding influences of the atmosphere, or by the sea, before being covered by the boulder clay, but whether that be so or not, the most careful search has been

made, without finding the slightest evidence of ice anywhere to the east of Liverpool, and under the great advantages presented by the very frequent excavations open for building purposes. If the ice were a glacier confined to the valley of the Mersey, its thickness in the centre was about 300 feet, but there is a strong probability that ice covered the whole of this part of the country, and in that case it must have been much thicker.

NOVEMBER 13TH, 1866.

THE PRESIDENT, ROBERT A. ESKRIGGE, F.G.S., in the Chair.

FRANK ARCHER, B.A., and WILLIAM W. ROBINSON, were elected Ordinary Members.

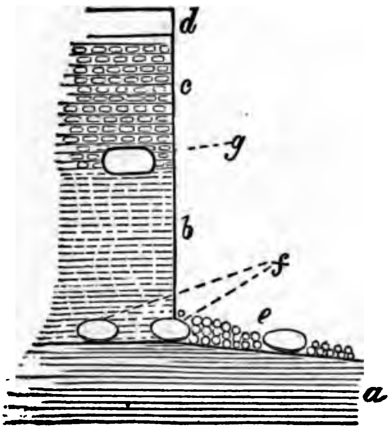
The following communications were then read :—

ON THE OSCILLATIONS OF LEVEL ON THE COAST OF HAMPSHIRE DURING THE EOCENE PERIOD.

BY CHARLES RICKETTS, M.D.

THE Chalk, the lowest formation which occurs in the South of Hampshire, makes its appearance at the surface on Portsdown Hill, overlooking Portsmouth Harbour. Upon it is situated the Plastic Clay (i^2), which was well exposed in making Wallington Fort, near Fareham, and is also seen on the road to Funtley, two miles north of Titchfield, consisting chiefly of red and white mottled clay, and coincides with descriptions given of the same formation in the Isle of Wight. Above this is the London Clay (i^3) which, though in the Isle of Wight it attains the thickness of two hundred feet, cannot, in the neighbourhood

of Fareham, be more than seventy-five feet, calculating from its extent and the angle of dip (3°) as marked on the Geological Map; and near Funtley, judging from the depth between the overlying sands and the Plastic Clay, it does not exceed twenty feet.



The next series in ascending order is exposed at the base of the cliff section, from Browndown Point to Stubbington Lane end, and between it and low-water mark. It consists of a series of sandy clays and clayey sands (*a*), of a dark green colour, abounding in fossils, and considered by the Rev. O. Fisher, in the Quarterly Journal of the Geological Society for 1862, as Bracklesham beds (i^5). These fossiliferous beds are covered by about twelve or fourteen feet of a greyish-coloured loose sand (*b*), quite unfossiliferous; superimposed on this sand is a bed of ochre-coloured gravel (*c*), consisting chiefly of waterworn chalk flints, with a thin stratum of vegetable mould above (*d*).

Of these strata, the Bracklesham beds are nowhere exposed inland, but the whole district forms a table land of gravel, with its underlying bed of sand, from beneath which emerges the London Clay.

At the base of the cliff at Stubbington, amongst the shingle (*e*), which is composed of the waterworn flints from the upper stratum, are a number of boulders, a few consisting of sandstone, but the great majority of the same

material, and containing the same organic remains, as the fossiliferous beds, excepting that they have become consolidated. Some of these fossiliferous boulders (*f*) are seen in situ at the base of the cliff resting upon the Bracklesham beds; whereas, large sandstone boulders (*g*) are occasionally exposed in the cliffs at the junction of the sand and gravel, and there is one of them lying in a sandpit, near the road to Crofton, about one and a-half miles inland.

It thus appears that in the interval between the deposition of the Bracklesham beds and the unfossiliferous sands, an upheaval must have taken place, exposing the strata to denudation, which extended more inland as low down as the London Clay; that after a subsequent depression, which permitted the deposition of the sandy strata, a change of level has again occurred, during which the higher beds have been removed, the boulders seen upon the shore remaining as a record of each event.

Such being the case, it appears that there must be an error in the Geological Map as to the proper sequence of the strata, as it is evident that the sandy beds which are marked (i^4) as being the equivalent of the Lower Bagshot beds in the Isle of Wight, have been deposited at a period subsequent to the formation of the Bracklesham *beds* (i^5).

NOTES ON THE GEOLOGY OF LEICESTERSHIRE.

By G. H. Morton, F.G.S.

DECEMBER 11th, 1867.

The President, ROBERT A. ESKRIGGE, F.G.S., in the Chair.

The following communications were then read :—

ON THE DRIFT SECTIONS OF THE HOLDERNESS COAST, YORKSHIRE.

By Hugh F. Hall, F.G.S.

In his Illustrations of the Geology of Yorkshire, published in 1829, Professor Phillips enters into a detailed description of the Coast of Holderness, and of the general geology of the district. In this he states that the chalk rubble at Hessle, containing bones of horse, ox, deer, and mammoth, is overlain immediately by a mass of clay and pebbles, which underlies all Holderness, and in the highest cliffs on the coast is not less than one hundred and thirty feet in thickness. He also refers to "patches" of sand and gravel being found enclosed in the great deposit of clay at Dimlington, Skipsea, and Bridlington, and to the great accumulations of gravel at Brandesburton (where an elephant's tusk had been found), Paghill, and Keyingham (Kelsey). He enters into some details of the shells found in these gravels, and draws the conclusion that they are more recent than the crag formation. He then calls attention to the lacustrine deposits with peat and freshwater shells, and remarks that shells are not found in the marl above the peat, only in that below. He adds the fact that in these deposits are found the remains of oxen and deer (Irish elk, the red deer, and the fallow deer), with trees and fruits, and refers the whole of them to one age. He epitomises his description as follows :—"Of the diluvial accumulations, by far the most prevalent, that which is the base of the whole cliff, is blue and brown clay containing dispersed pebbles; above this a more local deposit of undulated laminated clay, and finally gravel on the top, or mixed with the pebbly clay. In this formation lie the

teeth and tusks of antediluvian elephants, and abundance of waterworn fossil shells, derived from neighbouring and remote districts. Resting on these diluvial beds we find the deposits of later, more quiet, and contracted water, lakes which existed in hollows of the deluge-worn surface having been slowly filled up by clay marl, shells, and peat subsiding from their waters. The shells which occur in these clay beds belong to freshwater species now living—they lie almost invariably at the bottom of the bed of the lake, and are covered by several feet of clay and peat *without shells*, a circumstance which seems to warrant the supposition that the upper layers of sediment and peat were produced in some short period of time, in consequence, perhaps, of great land floods. In these deposits lie the skeletons of postdiluvian animals—the great extinct elk, the red deer, the fallow deer, and the ox. In more than twenty examples on the coast south of Bridlington it may be clearly seen that the lacustrine deposits rest upon the diluvial accumulations, but are not themselves covered by any other deposit."

It will be seen from the above that he then supposed that the whole mass of deposits of clays and gravel were one formation, only distinguished by the variation of their constituent parts, and succeeded by a freshwater formation in parts overlying the former. The divisions of stratification, and especially the two examples of unconformability, which I shall afterwards detail, do not seem to be anywhere noticed.

In the Quarterly Journal of the Geological Society for 1861, vol. 17, Mr. Prestwich called attention to the occurrence of *Cyrena Fluminalis* in beds at Paull and Kelsey Hill, near Hull, overlying the boulder clay, along with many other shells, all estuarine or marine. Great

interest attached to this discovery, on account of the occurrence of the same remarkable shell in the sand and gravels of Abbeville, with the flint implements which have caused so much discussion in the scientific world. To prove his argument, he gave detailed sections of the Ballast Pit at Kelsey Hill, to which I will hereafter refer, merely remarking now that he states that " the coast section from the Humber to Bridlington shows cliffs of boulder clay capped here and there by similar gravels, but not so fine and sandy. " Well sections," he continues, " throughout Holderness also show the boulder clay to extend inland to Hull and Beverley." He goes on to state, that to be certain of the superposition of these gravels above the boulder clay, " he proceeded to examine the river side section described by Professor Phillips at Paull Cliff, where he found similar beds, containing Cyrena, overlying an irregular surface of grey clay," which he states his friend Mr. T. J. Smith, F.G.S., of Hull, subsequently determined as the boulder clay. He gives the section as he saw it. The well sections at the end of the paper are very interesting. These are the only papers I know of that describe this district.

During the last summer I spent some time examining the coast sections of Holderness from Kilnsey to Flambro' Head. I am indebted to my companion, the Rev. J. L. Rome, F.G.S., of Hull, for being able, in the time at my disposal, to examine so many of the most interesting sections, both on the coast and inland, and also for much valuable information, especially for calling my attention to the continuous range of what I shall venture to call the " Hessle clay" over the whole district from the coast to the chalk wolds. The great interest and value of this observation of Mr. Rome I hope to develope in the account of the district to which I shall now ask your attention.

Holderness is the name given to that district of Yorkshire which is bounded on the north and west by the Chalk Wolds, on the south and southwest by the Humber, and east by the sea. It extends about forty miles in a north and south direction, by an average width of ten miles east and west. The whole of this district is covered with a series of clays, gravels, and sands, principally the result of marine deposition in Tertiary and subsequent seas, which washed the chalk wolds upon the west, forming a great bay from Flambro' Head on the north to Cromer, in Norfolk, on the south, extending upwards of 100 miles in a direct line from point to point. It will be my endeavour to elaborate, as far as my observations went, the general sequence of deposition, though I am quite aware that the too limited time I had to dispose of must have prevented my taking into account many circumstances which may vary or alter particular facts in their relation to each other when considered in reference to the whole district. The general surface appearance of the district is flat, and beyond the beauty which is always imparted by good cultivation and trees, has nothing to recommend it in a picturesque point of view. The rising grounds, locally called hills, are nothing more than gentle swellings of the surface caused by irregularity of denudation, and it is only from the sea shore that you can see anything worthy of the name of a hill, the highest land, viz., Dimlington Heights, being only about 150 feet above high water level. The very soft nature of the whole of the materials forming the sea cliffs enables the waves to act upon them with great effect, and as a natural consequence, considerable areas are being rapidly denuded to form new deposits on our present sea bottoms. The sites of several villages, such as Auburn, Hartburn, and Hornsea Beck, are marked on the Ordnance Survey maps as now covered by the sea; and two churches

at Kilnsey and Owthorne are in ruins, the base of which the sea washes at every returning tide. Should nothing intervene to counteract the present operation of the sea, the time may be calculated when the wolds may again become, as they have been before, the rocky boundary against whose cliffs some future storms may dash the waves in foam. The work of destruction, however, will be less powerful in the future than in the past, as subaërial denudation is now to a large extent arrested in its assisting efforts by the great systems of artificial drainage, which have turned tens of thousands of acres of a formerly marsh waste into valuable corn lands, the more rapid carrying away of the superabundant rainfall by these channels preventing the destruction of cliff which, in past ages, when the overladen earth groaned with the vast weight of waters soaking through it to find vent, must have made it a much more easy prey to the attacking waves. In a country like this the shore presents at once the easiest and best means of obtaining sections, and accordingly, commencing at Kilnsey, which (with the exception of Spurn Head, a long low promontory of sand, over which the sea washes in rough weather) may be taken as the most southern point, I will call your attention to the section exhibited in the cliffs called the Dimlington Heights, extending northwards as far as Withernsea, a distance of about nine miles.

Section at Dimlington.—Taken about centre of the Head.

1.—Hessle red clay, facing blue ....about	10	feet.
2.—Hessle gravels and sands, yellow	10	,,
3.—Purple clays, unstratified	80	,,
4.—Finely laminated alternate yellow sands and clays—the clays red at top, grey at bottom......................	15	,,
5.—Finely laminated grey clay..........	4	,,

6.—Fine chalky gravel .... 3 feet.
7.—Solid grey clay.................... 4 „
8.—Black earthy clay .... 6 inches.
9.—Solid grey clay, with scratched and polished boulders................ 20 feet.

At Kilnsey the land is low, and the only divisions of the Section to be seen are Nos. 1 and 2, the purple clay No. 3. occasionally cropping up in bosses and disappearing again until some distance has been gone over to the north, when it comes up permanently, still showing an irregular denuded surface, and eventually it reaches its ultimate depth of eighty feet about the centre, where the cliff attains a height of about 150 feet.

No. 1.—The Hessle clay is a very even development of about ten feet in thickness, covering the whole cliff from Kilnsey to Withernsea, though here and there wanting through the effects of denudation. Its thickness does not increase with the height of the cliff, and it follows the semicircular form which the cliff assumes, the previous purple clay hill having had the same form, and the Hessle clay apparently having been deposited in the position it now has on the previously denuded surface of the purple clay No. 3, dipping towards the south at the southern, and to the north at the northern extremity of the Heights. It is of a brick red colour, breaking with a blue surface to the joints, contains few large pebbles, though a good many small ones, and is characterised also by containing fragments of coal smut. Its colour is so distinct from any other clay seen in Holderness, that it is impossible to mistake it for any of the many other beds that occur.

No. 2.—Yellow sand and gravels, is a thin band at Kilnsey, but becomes thicker towards the north, attaining its maximum about the centre of the Heights. Farther

north it varies very much, in places being altogether denuded, in others continuing as a mere line, and again swelling out to several feet in thickness. The gravels are not regularly interstratified, but are in patches, and sometimes running in lines among the sands, giving the appearance of false bedding, diverging in every direction, and breaking into all sorts of inequalities. The pebbles are small, principally chalk, and in places having a yellow appearance, probably from being discoloured with iron. In others they retain their original greyish tinge, which is heightened by veins as it were of coal fragments running through it. These gravels, as will hereafter be seen, seem invariably to accompany the Hessle clay, and may, perhaps, be properly called the Hessle gravels. The coal smuts I have not noticed in the lower gravel beds as seen in shore sections. These gravels also follow the previously denuded surface of the purple clay.

No. 3.—Purple clay, as I have already stated, crops out in bosses as one proceeds northward from Kilnsey, running up as it were into the gravels above them. This irregularity of surface, sinking in hollows of denudation, is persistent along the whole section, and not only here, but as will be hereafter seen, throughout all Holderness. It dies away again after attaining its maximum of eighty feet, and near Withernsea only appears in bosses as at its southern outcrop. This is the "boulder clay" of Mr. Prestwich; but I cannot see just ground for a similar belief, as though it is an unstratified mass, yet it contains exceedingly few pebbles of any kind, and the few scratched pebbles that may be picked out here and there by search, I think are quite as likely to be there by the redistribution of what I take to be the true boulder clay below this, or from the grounding of floating icebergs, as from being

deposited during the Glacial Period. I think, had this been a deposit of the Glacial Period, the number of scratched pebbles and of blocks and boulders generally would have been much more plentiful than they are shown to be by actual observation. I could find no shells in this deposit, though I would found no argument on my want of success in this respect, had I not been assured by Mr. Rome, who is familiar with the district, that his own search had also been in vain, and that he had never heard of any being found.

No. 4.—Is an exceedingly delicately-marked series of laminations of yellow sands and of clays which occur only in the denuded hollows of the grey clays, No. 7 and 9, hereafter to be noticed. These thin out very much towards the south, where the alternate layers of sand and clay are about equal in thickness, but very fine, probably four to ten layers to an inch, indicating probably deposition in very still water of an estuarine character, where the spring tides flowing in would bring particles of sand, and the outflow would carry down the fine mud borne in the mingled river or marsh waters finding their way to the sea. These clays are red at the top of the deposit and grey at the base, the colours gradually running into one another. As we proceed northwards the sands increase in thickness to about a foot, while the clays remain the same fine laminæ, which would suggest that the sea which deposited these muds and sands deepened, enabling ordinary tides to carry siliceous fragments in larger quantities to these parts, while only extraordinary floods of freshwater would be able to bring down sufficient mud to cause an interruption in the deposition of sand. There are but few small pebbles in this division of the section.

No. 5.—Is astr atifiedd eposit of grey clay, also occurring

in the denuded hollows of Nos. 7 and 9, and is seldom to be seen separate from the sands and clays called No. 4. It is doubtless the result of the denudation in a shallow sea of Nos. 7 and 9; the strata are only one quarter to one inch thick, and contain very few pebbles.

No. 6.—Fine chalky gravel is sometimes seen in the hollows of 7 and 9, below the clays No. 5; in many places it indicates itself as a mere line of gravel, but occasionally developes a thickness of two to three feet, but always following the denuded surface line of No. 7.

Nos. 7 and 9.—These are substantially the same deposit. They appear only where the Heights attain an elevation of about 120 feet, and are again lost in the shore as you go northwards. Their base is not seen, and their thickness therefore is uncertain. The surface is hollowed out into deep valleys of denudation, and is unconformable to the deposits overlying it. Were any one of its divisions seen separately it might be said to be unstratified, but as seen, it is divided into three considerable divisions, the lines of stratification being perfectly horizontal, and being cut through by the valleys of denudation. It is composed of a very solid grey clay, full of chalk pebbles, and many more scratched and polished boulders of greenstone, mountain lime, mica schist, gneiss, and granite than are found in the purple clay before mentioned. It has a decided dip to the east. A band of very fine chalk gravel runs unevenly through it. The boulders and pebbles are most plentiful at the base so far as seen, the upper parts of the bed containing only a few quartz, silurian, and volcanic pebbles. About four feet from the top of No. 7 there runs a band (No. 8) of black earthy clay, about six inches thick, which is difficult to account for.

No shells are to be found, so far as I could learn, in

these grey beds, but I have a strong feeling, almost amounting to conviction, that these beds, Nos. 7 and 9, will be found to be the *true glacial boulder clay.* From the centre of the Heights, where these deposits appear, to Withernsea, the reverse of what has occurred since we left Kilnsey takes place. The purple clay No. 3 is there again the base bed.

Now, in order to make this and the following sections more intelligible, I shall here describe the section at Hessle, taken in the railway cutting, where the wolds may be said to begin in the south of Yorkshire, and from the name of which place I have ventured to distinguish the uppermost beds of clay and of gravel, which, as far as my own observations went, and from the more extensive observation of Mr. Rome, extend over the whole of Holderness.

1.—Red clay, with blue surface to joints, many small pebbles, chiefly chalk fragments of coal	about 10 feet.
2.—Sand and pebbles..................	1 „
3.—Broken chalk	6 „
4.—Solid chalk, base not seen.	

The surface bed of red clay No. 1 exactly corresponds with that described in Dimlington section as No. 1, and the gravel below (No. 2), though not largely developed, has the characteristics of No. 2 bed in the same section. On the opposite side of the railway it is in places four or five feet thick. No other beds intervene between these beds and the chalk below. Thus it would appear that the uppermost beds in the eastern coast section are the only beds which overlap the chalk in the extreme west, evidencing a deposition not only more recent but more extensive than the underlying deposits. The chalk rubble under this has no appearance whatever, so far as I could trace, of being

redeposited, and I should take it only as an old surface broken up by weathering, and perhaps ice-cracked. None of its fragments are rolled at all, and the joints become fewer and the blocks larger as you descend, until it runs into the usual solid layers of stratification of the chalk. The chalk shows a denuded surface, and is harder than that of the south of England, though much softer than the chalk of the north of Ireland. Bands of flints are frequent. I could not find any fossils. I was told that belemnites were occasionally obtained there. The rubble above the solid chalk is said by Professor Phillips to be the formation from which the rhinoceros and elephant bones were taken at Hessle. In the museum at Hull they are simply marked from Hessle. The only way in which I can imagine it possible that they can have been taken from this division is by supposing that they were found in some crack where the already broken rubble was mixed with the overlying gravels, which may have been washed in along with the bones, or that some cave has been filled (exactly as I saw one at Flamboro') with pebbles so as entirely to fill up the space previously hollowed out, and without careful examination it might be taken as a part of the broken surface. It is much more probable, however, that they were found in the overlying gravels. It is interesting to observe, however, that it is in these highest deposits (for I cannot admit that they were found in the chalk) that the remains of *Elephas primigenius*, horse and rhinoceros were found associated.

At Out Newton, where the cliff descends almost to the shore before quite reaching Withernsea, a new element is introduced, as will be seen in the following section:—

1.—Hessle clay........................ 2 feet.
2.—White marl, with plants and shells.... 2 „
3.—Gravels? freshwater .... 2 to 5 „
4.—Purple clay.

In this section the Hessle clay lies in direct superposition to the purple clay to the south, and covering a bed to the north of the section of white freshwater marls, which has been deposited on gravels, which may either be of freshwater origin, as may be suspected from their absence immediately to the left, or may be the shore condition succeeding the purple clay, on which, on further elevation, a freshwater mere, such as appear to have been very common over the whole district, has afterwards been formed. The deposit contains very beautiful impressions of leaves, and also freshwater shells, valvata, limnea, cyclas, pisidium, sphœrium, bithynia, and cypris. The section, as I saw it, appeared as if the white marl disappeared under the purple clay, but as the exact point of junction was covered with a fall of the upper clay bed, I would rather take it that it rests against it until I can satisfy myself on this point.

From Withernsea to Hornsea I had no opportunity of seeing the coast. At the latter place, most of the sections I have taken refer more particularly to the lacustrine deposits, but as in the limits of the present paper I cannot hope to go into such detail as I should wish in regard to them, I must defer the description of them till later in the session. I shall confine myself therefore to one section only—that which includes nearly all the divisions of stratification there exposed. I regret that in this section I have omitted to take memoranda of the depths, though, as of some of them only the indications are present, such depths would not be of much value.

South of Hornsea Gap the Hessle clay is seen above the gravel, so that we would have in a consecutive order—

No. 1.—Hessle clay (not seen in above section.)
No. 2.—Hessle gravels, horizontal, but partially false-

bedded fine yellow sands and grey gravels, and covering the denuded edges of Nos. 3, 4, 5, and 6.

No. 3.—Brown earthy clay and fine sands, dipping to south at considerable angle.

No. 4.—Coarse yellow gravels, dipping even at a greater angle than above.

No. 5.—Earthy black clay with lake shells, same dip as No. 4.

No. 6.—Blue and grey earthy clays with lake shells, six feet.

No. 7.—Purple clay rising in a boss.

Here we see the same order of succession developed, as far as it goes, as in the Dimlington section, except that the freshwater beds, No. 3, 4, 5, 6, are more largely developed, and are *below* the Hessle gravels, and not above them. Immediately inland lies the Hornsea Mere, the largest lake in Yorkshire, which is a very good existing example of what must have been very general immediately after the elevation of the purple clay. Many of these are now drained, or exist only as reedy wastes. The Hornsea Mere empties itself into the sea at Hornsea Gap through a great marsh, the depth of which, as ascertained by boring when the railway extension was brought over to the shore, has been stated to be about 1000 feet, and which in itself may be considered as an enormous water reservoir.

The section at Whitto Hole I must also reserve for my paper on the lake beds, remarking only that the purple clay, which is there again the base bed, comes up in bosses, showing denuded surface.

The next sections I will describe are two seen south and north of Bridlington Quay, the latter running up as

far as Flambro' Head, which bounds the district on the north.

The south section is as follows:—

No. 1.—	Clayey humus, with gravel......	3 feet.
2a.—	Chalk gravel, running into & under	3 „
2b.—	Yellow sands, which widen out to a great thickness, say............	10 „
2c.—	Finely laminated sandy clay beds, showing wave-ripplings........	15 „
3.—	Sandy brownish purple clay, unstratified, lost in shore. I take this to be purple clay bed of other sections	20 „

The north section is

No. 1.—	1 a, white marl, with shells; 1 b, peat; 1 c, darker grey marl, without shells	8 feet.
2.—	Gravels, nearly all chalk........	20 „
3.—	Purple clay, breaking into cubes, unstratified..................	30 „
4.—	Dark gravels, often bound closely with earth and clays..........	4 „
5.—	Stratified grey clay, few pebbles..	6 „
6.—	Very fine chalk angular rubble, much larger at base, running at last into	
7.—	Chalk, almost horizontal, dipping northeast.	

In these sections also we find the same general order of deposition, although the individual layers show variation. Thus the three feet of clayey humus with gravel is too indistinct to be identified with the Hessle clay, probably from the constant disturbance of cultivation, which is here carried on to the very edge of the cliff, having added to it so much vegetable refuse as to alter its appearance materially.

Again, we find that the gravels, which, from their position, I take to be the Hessle gravels, are enormously developed, attaining a thickness in its three divisions of chalk-gravel, yellow sands, and sandy clay beds, of no less than twenty-eight feet. This may be the result of the denudation being much less in consequence of the shelter of the Flambro' Head, which pushes into the sea only a few miles off, and the proximity to this Head may also explain the upper division being composed almost entirely of chalk-gravel; the yellow sands and sandy clays also once having been deposited in such a sheltered position, would thereafter be little disturbed, while farther south the more exposed nature of the coast would enable the encroaching waves again to gather up the lighter particles of sand, and carry them onward for further distribution, while the heavier gravels would be gradually rolled more slowly southward, mixing as they went with those denuded from the exposed surfaces of the grey and purple clays. The placid nature of the waters in this basin is also evidenced by the distinct ripple markings in the beds marked 2 *c*, where the particles of clay mixing with the sands have left the traces of the former action of the waves exposed in a way which unimpressionable sand alone would not record. These sands become much thinner to the north. North of Bridlington Quay, and south of it, a very extensive lake covered at one time the gravels. In descending section, we have first, a white marl (1 *a*), *with shells* such as I before named, followed by peat (1 *b*), and that by darker grey marl *without shells* (1 *c*), in all attaining a thickness of eight feet. Towards the north the darker grey marls become very white. The gravel beds No. 2 increase in thickness from about ten feet south to twenty feet at the north, another evidence of the want of power in the current to carry away the more ponderous

fragments (rolled about by the waves) which have fallen from the chalk cliffs. The pebbles are nearly all chalk—grey and yellow, the latter stained with iron. These gravels run very horizontally (as indeed do all the strata north of Bridlington Quay), the only exception to this being where the bosses of purple clay come up, the gravels in the hollows between them show that they have tumbled in, the indications of stratification becoming more horizontal as it rises above the top of the boss.

The purple clay all along this section shows denudation, valleys of twenty feet and more being cut into its surface. It is unstratified—breaks into cubes, but never shows the blue facings of the Hessle clay. About halfway to Flambro' Head, three to four feet of dark gravels, often bound closely with earth and clay, crop out, but die out just before reaching the Head. As you near the Head it is much more difficult to make out the section, as the upper deposits have fallen over those below in the way in which those who are familiar with these loose materials will readily understand. However, there are traces here and there, and in some places sections three to six feet thick may be seen of the grey clay coming up in bosses, as we saw it did at Dimlington, and showing us there also decided stratification. The pebbles, however, are few, which you will remember was characteristic of the upper grey bed at Dimlington. Its real thickness it was impossible to make out here, and I do not wish it to be understood that six feet was its absolute thickness, but that that was the utmost that could be seen in any one place. About 200 yards south of the Chalk Headland a bed of very fine chalk angular rubble, mixed with a yellow paste, appears, and increases in thickness till it attains about thirty feet. The size of the fragments increases greatly as it increases in thickness, and also as it nears the solid chalk,

until at last it may be said to run into the regular layers of stratification, as it would be impossible to say which was the one and which the other. I take this to be the result of the action of sea and frost, each contending for the mastery, sometimes leaving the exposed surface of the cliff to the melting influences of the waters, and again exposing it to the dividing effects of congelation. It is the same on a much larger scale as that which I have already noticed as occurring at Hessle. The bed seems to cover the whole mass of the solid chalk of Flambro' Head. It will be noticed that here the yellow sands which attain such a thickness only a few miles farther south are entirely wanting, which, I think, may be explained from their not being derived from the immediate locality, but probably from the denudation of the oolitic strata to the north. The currents bearing these particles as they rounded Flambro' Head would naturally set in a more direct line south than the coast line, and would thus only again meet the present shore at some distance southward, apparently just about where Bridlington now stands. The chalk gravels, on the contrary, being the result of the denudation of the angular bed before described, are here in much greater thickness, and become thinner the farther south they go.

The only remaining section I have time to call your attention to is that of Kelsey Hill, which, though not a coast section, is valuable, like that at Hessle, for the better understanding of the others. It is used as a ballast pit for the railway, and a great deal of it is covered by the fallen debris of the upper beds, but, taking the west to east section as exposed, the following could be easily made out, viz.:—

No. 1.—Hessle clay	....	15 feet.
2.—Red clayey sand, very firm	......	4 ,,
3.—Gravel	....	2 inches.

4.—Soft brown sand................ 1 foot.
5.—Gravel........................ 1 inch.
6.—An immense mass of stratified sands and gravels, false-bedded, but so broken up that no section could be made out................about 60 feet.

Here again we have the Hessle clay as the surface bed, and although I have attempted to divide the succeeding beds more minutely perhaps than is necessary, yet I have no hesitation in expressing my belief that the whole of this great mass of gravels and sands is the equivalent of the Hessle gravels, collected in a greater mass, probably through the action of currents, it may have been as the bar to some river which here poured into the then sea, and which brought down with its water the *Cyrena fluminalis* which so incongruously is found lodged among the marine shells which are there so abundant. May not the same supposition of its being the bar of some river be an explanation why here are found such an abundance of remains of animal life, which are absent in the other places where the same gravels are seen to occur. Their food would here be so much more plentiful that they would naturally be found congregated in immense numbers. The current of the daily tides also forcing their way up such a narrow channel would have the effect of carrying dead shells with it, and accumulating them at the spot where the conflict of the waters forced them to drop the daily freight. Mr. Prestwich seems to have entirely overlooked the existence of the Hessle clay *above* the gravels, the observation of which by Mr. Rome over the district serves to elucidate the exact position of these gravels, and to add another argument to those Mr. Prestwich urges to show their superposition to the boulder clay, which the scope of his paper, and especially his reference to the Paull

section, shows he understands to be the purple clay, which comes out at Paull just in such bosses as are seen elsewhere. I also think that these gravels are above the boulder clay; but I go farther, and think that the purple clay is itself a great deposit lying between the gravels and the boulder clay.

I will now call your attention to the very interesting borings given by Mr. Prestwich at Pollard's Farm and Twier's Farm, for the purpose of correlating them with the sections at Dimlington Heights on the south, and at Bridlington Quay on the north, which give us some very interesting results. Leaving out the surface soil, we have in each boring section a bed called "red brick clay" at Pollard's Farm, and "good brick clay" at Twier's Farm, which, I think, we may with probability set down as the equivalent of the Hessle clay in both the Dimlington and Bridlington sections. We then find thirty-four feet of "black warp" at Pollard's Farm, and thirteen feet at Twier's Farm, the latter being more to the north by about a mile than the former. This I take to be the mud of a postglacial estuary, and the difference of thickness gives the clue to the dip from north to south of the bottom of that water. This is more strikingly brought out, when we take the depth of the next formation called "red clay with stones," and "strong marly clay with stones," which I take to be the equivalent of the purple clay. If we take the sum of the warp and red clay at Pollard's Farm—say, thirty-four and twenty feet, we have fifty-four feet, and, acting in the same way with the same deposits at Twier's Farm—say, thirteen and forty feet, we get fifty-three feet, or a nearly equal depth, giving us at once the amount of denudation to which the purple clay had been exposed as being twenty feet more at the former place than the latter, and consequently that the shore might (car-

rying on the dip at the same ratio) be expected just about where Kelsey Hill with its shells is situated. With the knowledge, however, of the extensive range of the Hessle clay, I cannot accept Mr. Prestwich's supposition that the red clay here found above the warp, and the warp itself, are "probably the alluvial deposit of the marshes." It is more agreeable, as it appears to me, with the whole evidence I have adduced, that a marine estuary existed occupying a much more extensive area than the present Humber, but following generally in its course. The "rough gravel and sands" will be found to correspond with the fifteen feet of sands at Dimlington and four feet of gravels at Bridlington. Their greater thickness need hardly be discussed, when we remember the exceedingly changeable character of gravel deposits of our present shores. Below these rough gravels follow at Pollard's Farm "very fine clay, clear of stones, eight feet," at Twier's Farm, "fine clay, one foot," at Dimlington, "finely laminated grey clay, four feet." These I take to be equivalents. The grey clay at Bridlington (six feet) is not laminated, and I think is not to be accepted in this position. Below these, "the bed of flint" at Pollard's Farm, and the "dark green sand" at Twier's Farm, may be correlated with "fine chalky gravel" at Dimlington. This is quite wanting at Bridlington. Leaving out the "black moor decayed wood" at Pollard's Farm, I think we may take the next three divisions at each of the farm sections together, and find their equivalents in the three divisions of "solid grey clay" called No. 7, at Dimlington, and in the "stratified grey clay," No. 7, at Bridlington. Lastly, we find two divisions at each of the farm sections called chalk, but evidently, from their separate classification, showing some distinction, and these I would find in the "chalk angular rubble" and "solid chalk" at Bridlington, and I think it

very probable that not very far below the shore level at Dimlington the chalk might be reached by boring, within say twenty feet. I might also refer to the well sections, given at the end of Mr. Prestwich's very interesting paper, in support of parts of the above correlation—especially that at Withernsea—but having already occupied too long a time in this paper, must leave the examination of it for themselves to those who are interested in it.

CONCLUSION.

In conclusion, I shall endeavour to trace the conditions under which the various deposits existed, as deduced from the evidence I have brought before you. Reversing the order in which we have been considering them, and leaving out of consideration the existence of the Bridlington Crag, as I am now describing only what came under my own observation, we find—

1st.—Chalk, dipping N.E. See No. 4 Hessle Section, and No. 9 Bridlington Section.

2nd.—The surface of this chalk, broken up probably by the action of frost during the Glacial Period into rough angular fragments, becoming much smaller the nearer to the denuded surface, both at the Flambro' and Hessle terminations of the chalk wolds. See No. 3 Hessle Section, and No. 8 Bridlington Section, No. 12 Old Pollard's, and No. 11 Twier's Farm.

3rd.—A depression, which cannot have been less than fifty feet, but may have been much more, during which the solid grey clays No. 7 Dimlington Section, No. 7 Bridlington Section, and Nos. 9, 10, and 11, Pollard's Farm, and 8, 9, 10, Twier's Farm Section, were deposited. That this deposition did not take place without breaks appears to be evidenced by the three divisions of stratification in which it

is found, each of which appears to have been of somewhat different constitution from the others. This deposition must have taken place during the glacial period, as is evidenced by the scratched and grooved boulders to be found in it. The fewness of these boulders may be accounted for, perhaps, by the deposit having been made in comparatively still water; or if we are not to accept this as the true boulder clay, we must, because of their paucity, then conclude that it is a still more recent deposit than I have represented it to be, and not an older one, as is necessitated by the supposition of the purple clay being the "boulder clay" of the Glacial Period. Dip east.

↑ 4th.—Subsequently this "grey clay" has been uplifted and exposed to a considerable amount of denudation, as is shown by the hollowing out into valleys, and by the unconformability of the overlying strata.

↓ 5th.—Another depression, probably very slow and gradual, leaving it for a long time in a shore condition, depositing first,

6th.—The chalk gravels No. 6 Dimlington, which may be taken as the rolled chalk rubble No. 8 Bridlington, gradually carried south by currents, and dark gravels No. 6 Bridlington, which, being near Flambro' Head and westward of it, appears not to have been under the influence of the current mentioned above, and consequently the gravels here are those washed out of the denuded clay, with but few chalk pebbles, but both resulting from the action of the same sea. See also No. 7 Pollard's Farm, and No. 7 Twier's Farm; and secondly,

7th.—Finely laminated grey clay, evidently the result of denudation of No. 7 Dimlington section deposited in quiet waters. At Bridlington, where, as we have seen, the deposit of grey clay No. 7 is but slight, this is wanting,

unless we may suppose the earth and clay which there bind the dark gravels No. 6 to be its equivalent, as is not unlikely. These two deposits, Nos. 5 and 6, occupy at Dimlington the troughs of denudation, and rest against their sides unconformably. See also No. 6 Pollard's Farm, and No. 6 Twier's Farm.

8th.—The depression continued until the tops of the denuded hillocks of grey clay were below the water, and the beds of sand and clay No. 4 Dimlington were deposited, and being at that point doubtless approaching the limit to which the finer particles were washed seaward, the rougher and heavier particles dropped sooner, which are recognised in No. 5 Pollard's Farm, and No. 5 Twier's Farm.

9th.—The depression must then have continued for at least another hundred feet, though most likely much more, to admit of the deposition of the purple clay, which at Dimlington No. 3 reaches eighty feet in thickness, and is seen in No. 5 Bridlington, No. 4 Out Newton, No. 6 Hornsea, No. 3 South Bridlington, No. 5 Hornsea Station, No. 8 Whitto Hole; see also No. 4 Pollard's Farm, and No. 4 Twier's Farm. Unless, then, we place ourselves in the difficulty of supposing that there were two Glacial periods, with an interval of a comparatively temperate range, we must assume that this part of England had again returned to temperate conditions, while still the northern currents might bring down icebergs, which would deposit their freight of earth and boulders on its shores in considerable quantity. We can hardly suppose that the denuded surface of the grey clay No. 7, and the quiet deposition of the gravels and clays and sands, Nos. 6, 5, and 4 Dimlington, without any trace of boulders or scratched pebbles, is consistent with the continuance of glacial land conditions. Therefore I think we must take it that

although the temperature may still have remained a low one, it was sufficiently high at all events to have melted all the ice nearer than the Scotch and Westmoreland hills. The total depression shown by this series of deposits cannot have been less than one hundred and twenty feet.

10th.—The extensive denudation of this purple clay shows that an upheaval must have taken place to a sufficient height and for a sufficient length of time to allow for the hollowing out of troughs ten to twenty feet, although it is not to be supposed that the total denudation may not have been much more. That it was subaërial as well as marine, the presence of *Cyrene fluminalis* in the gravels deposited everywhere above the denuded surface, goes to confirm.

11th.—The gravels are seen No. 2 Dimlington, No. 4 Bridlington, No. 5 Whitto Hole, No. 4 South Bridlington, Nos. 2 to 6 Kelsey, No. 4 Hornsea Station, No. 5 Hornsea, at Paull, and No. 2 Hessle, from which I have ventured to name them. These contain many shells at Kelsey and Brandesburton (also inland), and Professor Phillips mentions the finding of an elephant's tusk at the latter place. I found a small piece of bone in the gravels at Kelsey, but too much broken to be determined. In the museum at Hull, however, there are specimens of bones of horse, rhinoceros, and elephant from Hessle, of elephants' teeth from Hornsea and Kilnsey, and of rhinoceros, elephant, bison, felis, deer, and horse from Bielbeck, near North Cliff. As to the last place I know nothing, but if you will refer to the sections at Hessle, you will see that it is impossible that these could have come from any other deposit, as not even the purple clay appears there, and at Kilnsey also there is no deposit older than these gravels, the purple clay only cropping out as you go northwards. At Hornsea,

also, the purple clay does just crop out, but it seems to me much more likely that the gravels, which at Hessle and Kilnsey I think there can be no doubt contained these bones, should also be their source at Hornsea. If, then, I show correctly, as I think I have done, that these gravels invariably overlie the purple clay, and that the

12th.—Hessle clay is not any part of the boulder clay, but invariably overlies the Hessle gravels, as at No. 1 Kelsey, No. 1 Dimlington, No. 1 South of Hornsea, No. 4 Whitto Hole, and No. 1 Hessle; then I think it is clear that we bring the existence of elephant and rhinoceros down to a much more recent date than has hitherto been received, the error having been incurred through the supposed identity of the Hessle clay and gravels with the boulder clay.

13th.—We have the subsequent elevation of the Hessle clay, and the occurrence on it of freshwater beds, which I propose to discuss in a subsequent communication, and will not therefore at present do more than refer to them.

I will conclude with simply remarking that there is a great similarity in the description of the St. Acheul beds with those at Hessle. A bed of "brick earth," followed by yellow sands and gravels, with land and freshwater shells, and occasionally marine shells, showing a similar estuarine condition with that I suppose to have obtained in Holderness at Kelsey, associated also with remains of elephant, rhinoceros, horse, and other mammalia, and these sands and gravels resting directly on the chalk. What further connection there may be between them, or if the one may help in the explanation of the other, I do not pretend to say. I have made this communication to you, aware of the many points which it leaves untouched, and of the deficiencies it is marked by, but in the hope that you will receive it as it is intended—as an endeavour after truth, in

the elucidation of the ways of the Creator, remembering that though in our examination of the earth's crust it reveals itself to us physically as the home and then the sepulchre of the created, yet we are impressed at the same time with the grander truth, that it is a stone in the palace and temple of the Creator.

LACUSTRINE DEPOSITS OF HOLDERNESS.

By Hugh F. Hall, F.G.S.

In consequence of the length which the former paper on "Coast Sections of Holderness" unavoidably attained, I was obliged to pass over with a mere notice the interesting evidences of land conditions in the freshwater deposits which are to be found in many of the sections. In some sort to remedy this defect, the present paper is offered to you.

It may not be amiss to recall that portion of the epitome of Professor Phillips' remarks which relates to lacustrine deposits. He says that these deposits of marl and peat do not contain shells in the marls *above the peat,* only in those *below;* and that in these deposits also are found the remains of oxen and deer (Irish elk, the red deer, and the fallow deer), with trees and fruits, and *refers the whole of them to one age.* "Resting on these diluvial beds," he concludes, "we find the deposits of later, more quiet, and contracted water, lakes which existed in hollows of the deluge-worn surface having been slowly filled up by clay, marl, shells, and peat subsiding from their waters. The shells which occur in these clay beds belong to freshwater species now living—they lie almost invariably at the bottom

of the bed of the lake, and are covered by several feet of clay and peat *without shells*, a circumstance which seems to warrant the supposition that the upper layers of sediment and peat were produced in some short period of time, in consequence, perhaps, of great land floods. In these deposits lie the skeletons of postdiluvian animals—the great extinct elk, the red deer, the fallow deer, and the ox. In more than twenty examples on the coast south of Bridlington it may be clearly seen that the lacustrine deposits rest upon the diluvial accumulations, but are not themselves covered by any other deposits."

The first lake section met with going north from Kilnsey is at Out Newton, where the Dimlington Heights cease to the north. Here we have a section as follows:—

No. 1—Hessle clay, as described in my last paper, 2 feet.
„ 2—White marl, with freshwater shells .... 2 „
„ 3—Gravels, freshwater?..............2 to 5 „
„ 4—Purple clay.

It will be seen that the freshwater deposit occurs below the Hessle clay, which overlies both it and, further south, the purple clay. The junction of the gravels No. 3 and marl No. 2 with purple clay is not seen in consequence of a downfall of the No. 1 Hessle clay covering the section, but the probability is that it lies above the purple clay, as in no case elsewhere have I found it below that deposit. It probably rests in a hollow of denudation of the purple clay, which, as we have seen, rises in bosses all along the coast. I did not attempt to collect all the shells that might be had here, though I brought away a few. The list given me by Mr. Rome, as found in all the beds, is as follows:—

Valvata piscinalis.	Cyclas.
Sphærium corneum.	Unio.
Bithinia tentaculata.	Pisidium.
Limnea, several species.	

I believe that Mr. Crosskey has also defined seven species of *Cypris (entomostraca)*.

This list is doubtless imperfect, and should I be able (as I intend) to again visit the district this year, I shall endeavour to collect as many species as possible.

This bed, however, is more remarkable for its botanical interest than for its fauna. The impressions of leaves and plants are beautifully retained in it, though from the soft clayey nature of its materials it is next to impossible to preserve them. I will not attempt to detail its treasures in this respect, but even to the unbotanical observer the variety and richness of these remains are of great interest. I shall be glad if the examination of them should fall into the hands of a competent botanist.

The greatest development of lacustrine beds occurs at Hornsea, where there are many sections. A few of these I have noted, and will describe. To the south of Hornsea Marsh there are marl beds; and marl beds with abundance of shells are finely exposed on the shore proceeding northwards, below highwater mark; but whether these are one and the same series of beds, I was unable to satisfy myself during my stay. If it should prove to be so, we have evidence of the existence of a mere in this place (close to the present Hornsea Mere), which must have rivalled it in size. The thickness of the beds is also worthy of attention, as they here attain a development of fully eight feet; and if we suppose the intermediate gravels to be fresh water, the section north of the hotel would show a thickness of fifteen feet. In fact, there is no distinction to be drawn between the gravels above the No. 4 marl bed of the North Hornsea section and the gravels and sand below, beyond a trifling difference of colour in places; they, in fact (where the marl beds thin out), *run into* one another. In materials of this

kind one does not expect a line of distinction, and it may be that we here have an example of the previously marine deposited Hessle gravels being overlaid by a freshwater gravel deposit, and mixed with it. The evidence which might be derived from organic remains has not yet been found in these gravels, and they are worthy of a diligent search, to identify, if possible, their marine or freshwater condition; at the same time, the existence of freshwater shells in them would, after all, only be evidence that what might once have been marine gravel had been redistributed under freshwater conditions. This section was the only place where I found the unio, and it is there in abundance in the lower lake beds. I was unable, from the slightness of the shell and the stiffness of the clay, to obtain any specimens worth bringing away, the disturbance of the beds breaking them to pieces.

In this section you will observe that there is a different arrangement of stratification from that at Out Newton. There the white marl beds came immediately under the Hessle clay, and above the gravels, and the same arrangement is seen on the south side of Hornsea Gap. On the north side we have, in addition to the white marl beds beneath the clay and gravels, a second series of white marl beds below the gravels, and overlying other gravels; and still farther north the Hessle clay is wanting, and the sands and gravels become the top bed, succeeding which, but apparently unconformable to them, are beds of earthy clay, dipping at a considerable angle to the south, succeeded again by another bed of gravels of different constituent parts and a yellow colour, followed again by earthy black clay with lake shells, and that again by blue and grey earthy clays, with lake shells, before we reach the boss of purple clay. Here, then, it appears to me, we have evidence of two distinct periods

of lacustrine conditions, between which, and following the last of which, a marine shore condition seems to have been resumed, in which the gravels were deposited, unless, indeed, it can be shown that one of these gravels may be of freshwater origin. All these sections following the above run north and south, but at Hornsea Station, in a road at the side, is exposed an east and west section following in sequence the section south of Hornsea Gap, but the dip of the marls east shows that at this point the lake shore was being approached inland, and that the lake extended seaward. The next section is at Whitto Hole, which again shows another variation in the order of superposition. Here a bed of peat five feet in thickness, full of nuts, overlies a bed of seven feet of white marl, which partly rests direct upon the Hessle clay, and partly on a bed of marl and yellow gravel, separating it from the Hessle clay. The Hessle clay lies on the denuded edges—first, of the purple clay; second, farther north, of a bed of coarse gravel about one foot thick, which follows the denuded mounds and troughs of the purple clay; third, of a finely stratified earthy clay filling up the hollows of the purple clay; and fourth, of the horizontally-deposited Hessle gravels and sands. Here, then, we have evidence of a third and later series of beds, now dry, as the result, as I believe, of the action of the present sea eating into and draining one of the lakes or marshes which must have been plentiful before the present extensive drainage system came into existence.

There are but two more sections to decide, and I have done. At Bridlington—both in the north and south sections—the white marl beds, followed in descending order by peat, and that by darker grey marls, overlying the Hessle gravels, show a nearly similar arrangement of beds to those seen at Out Newton and south of Hornsea Gap. Both these

marls contain freshwater shells, and although the peat shows a shallower condition at one time than at others, there can be no doubt that all these three beds are the result of one period of submergence under fresh water. It is difficult to say whether these beds were formed before, or subsequently to, the deposition of the Hessle clay, but the presence of that bed not far off to the south, makes it very probable that they were formed before it, and that their exposure as the uppermost beds is due to denudation.

I am quite aware that this slight examination is very far from an exhaustive one, and I have entered into it as a separate subject rather to make more complete my former paper, from which the omission of a notice of these beds would have been unpardonable, had time allowed of my adding it. Still we can arrive at some conclusions, which may be valuable, and to these I would now call your attention :—

First.—We have the evidence of *three* periods when these lakes existed since the upheaval and denudation of the purple clay, which, as I have before endeavoured to show, is greatly subsequent to the boulder clay period. These occur—

A.—Resting on the purple clay, as in the most northern section at Hornsea bed No. 5.

B.—Resting on the Hessle gravels, as at Out Newton, Hornsea Gap, both North and South Hornsea Station, and Bridlington.

C.—Resting on the Hessle clay, as at Whitto Hole.

Beginning, then, at the purple clay, we have, in ascending order, evidence of the following changes:—

1.—On its denuded surface, the formation of freshwater lakes and pools, evidenced by the fossil remains.

2.—The depression necessary to drain the lakes and accumulate a mass of sands and gravels in some places as much as twenty feet in thickness.

3.—An elevation sufficient to lift not only this thickness beyond the influence of the sea, but also to prevent the drainage of the freshwater poured upon them from escaping, by the elevation of the purple clay bosses and troughs on which it was deposited, otherwise the lake beds could never have existed in such a permeable stratum.

4.—Above these, on a subsequent depression, the Hessle clay has been deposited to an extent at least of fifteen feet; and finally,

5.—The elevation, which is probably that now subsisting, during which the Whitto Hole lake beds were deposited.

Second.—We see, moreover, that the remarks of Professor Phillips, that the freshwater shells lie almost invariably at the bottom of the lake beds, does not hold good. At Bridlington south section the shells are found both above and below the peat; and in the north section the *base beds* are without shells, while those above have them. At Hornsea his remark would be correct—but only there. There may be other beds (which I have not seen) on the coast which show the same thing, but the above examples show it is not a general rule, and that the deduction drawn from it, that their absence implies a rapid filling up, is groundless. Indeed, the fact of these beds being referable to three different ages prevents this assumption being relied upon; though it may be true in particular cases.

It would be curious to find from further observation that the "black moor decayed wood" in Pollard's Farm section, immediately above the "grey clay," which I take to be the

true boulder clay, might be the evidence of a moss upon its denuded surface, but it would be dangerous, from a single doubtful example, to draw such a conclusion.

Ever since the deposition of the grey clay (boulder clay), the conditions of this district of country have been particularly favourable, whenever its surface has been subaërial, for the formation of the freshwater deposits, the denuded clayey hollows of a flat country which has no sufficient natural drainage to carry off its surplus waters. This condition of things, indeed, remained within the memory of men now living, and that which in the beginning of this century was in great part a waste of pools and marshes, has only thus recently been changed into a smiling garden, the old lake bottoms affording admirable ground for the growth of corn crops. It affords us a striking instance of the influence which modern science has in producing great changes without any violent disturbance, in the very appearance of deposits which may, at some future day, be examined by the geologists of a subsequent date.

NOTE.—Mr. Marrat has kindly named the shells I brought home from these sections

Limnea truncata.	Helix hispida.
——— peregra.	—— pulchella.
Valvata piscinalis.	Cyclas cornea.
Planorbis vortex.	Succinea putris.
——— marginata.	Pupa marginata.
——— nautilus.	Bithynia impura.
——— spirorbis.	Pisidium.
	Unio.

Hornsea Section.—At Station, E. to W.

No. 1.—White marl, with freshwater shells 2 ft. 6 in.
2.—Grey gravels.................... 5 feet.
3.—Finely stratified yellow sands...... 5 „
4.—Yellow and grey gravels.......... 3 „
5.—A boss of purple clay.

Hornsea Section.—South side Hornsea Gap.

No. 1.—Hessle clay .... 5 feet.
2.—White marl, with shells .... 8 „
3.—Buff sand and gravel .... 4 „
4.—Purple clay...............20 to 30 „

Hornsea Section.—North side; 300 yards from Hotel.

No. 1.—Clay and earth.................. 4 feet.
2.—White marl, with thin peat bed (no shells) .... 1 „
3.—Grey gravels (freshwater?)........ 6 „
4.—Grey marl, freshwater shells ...... 8 „
5.—Sands and gravels .... 10 „

Hornsea Section.—Still farther north.

No. 1.—Horizontal, but partially false bedded fine yellow sands and grey gravels.
2.—Brown earthy clay and fine sands, dipping to south at a considerable angle.
3.—Mass of coarse yellow gravels, dipping even at a greater angle than 2.
4.—Mass of earthy black clay, with lake shells. Same dip as 3.

5.—Blue and grey earthy clays, with lake shells .... 6 feet.
6.—Purple clay rising in bosses.

MEM.—No. 1 lies on upturned edges of Nos. 2, 3, 4, and 5.

Out Newton Section.

No. 1.—Hessle clay .... 1 to 2 feet.
2.—White marl, with shells and plants.. 1 „
3.—Gravels ....1 to 2 „
4.—Purple clay boss.

Whitto Hole Section.

No. 1.—Peat bed, with nuts	5	feet.
2.—White marl	7	„
3.—White marl gravels	4	„
4.—Hessle clay	10	„
5.—Hessle sands and gravels	12	„
6.—Finely stratified earthy clay	4	„
7.—Coarse gravel	1	„
8.—Purple clay, in bosses	15	„

Shore Section.—South of Bridlington Quay.

No. 1.—White marl, with shells and pebbles	1ft. 6in.
2.—Peat	6 „
3.—Darker grey marl, no pebbles, shells	4 feet.
4.—Yellow sands and brown clays, running into fine chalk gravel, of great thickness to the south, abt.	12 „
5.—Purple clay denuded surface.	

Shore Section.—North of Bridlington Pier to Flambro' Head.

No. 1.—White marl, with shells	8	feet.
2.—Peat		
3.—Darker grey marl, without shells, but getting very white to north		
4.—Gravels, nearly all chalk	20	„
5.—Purple clay, breaking into cubes, unstratified	30	„
6.—Dark gravels, often bound closely with earth and clay, much fewer chalk	4	„

7.—Stratified grey clay, few pebbles . . 6 feet.

8.—Very fine chalk angular rubble, mixed with yellow paste, much larger pieces at base, running at last into solid chalk. . . . . 30 „

9.—Chalk, almost horizontal, dipping N.E.

Mem.—North of Bridlington all the strata lie nearly horizontal.

ON THE CAUSES OF GEOLOGICAL CHANGES.

By Robert Linton.

JANUARY 8th, 1867.

The President, ROBERT A. ESKRIGGE, F.G.S., in the Chair.

Dr. Hulse, of the United States of America, described some gaseous springs discovered by him near Rhyl.

The following communications were read:—

ON METEORIC STONES.

By Frederick P. Marrat.

ON SOME SECTIONS OF THE LIAS ON THE DORSETSHIRE COAST.

By the Rev. S. H. Booke, M.A.

FEBRUARY 12TH, 1867.

DR. RICKETTS, VICE-PRESIDENT, in the Chair.

The following communications were read:—

OBSERVATIONS ON THE SUBMARINE FOREST AND THE SEA SHORE AT DOVE POINT, CHESHIRE.

BY MR. CHARLES POTTER.

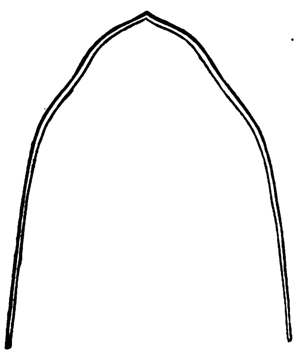
ON THE LACUSTRINE DEPOSITS OF HOLDERNESS, YORKSHIRE.

BY HUGH F. HALL, F.G.S.

(See December 11*th.)*

MARCH 12TH, 1867.

DR. RICKETTS, VICE-PRESIDENT, in the Chair.



He exhibited two specimens of the side spines of *Ampyx nudus*, which prove that in their natural position they extended beneath the edge of the cheeks to the point of the glabella, and were united together below the frontal spine, having been, probably, attached to the head by ligament only. It was suggested that as the occurrence of these spines is comparatively rare, they might possibly be a sexual characteristic.

The following communications were read:

MAMMALIAN REMAINS FROM CEFN CAVE.

PART I.

BY THOMAS J. MOORE, CORR. M.Z.S.

SOME two or three years since it occurred both to Mr. Frank Archer and myself that a small cave at Cefn, near St. Asaph, stated to be unexplored, or at most only partially examined, might well reward further research. Ultimately we determined to pay it a visit, and if on inspection it seemed likely to yield any animal remains we purposed to seek permission to excavate. Our preliminary visit took place in May, 1866, in company with Mr. G. H. Morton. The cave was found to have been but slightly explored, and it was thought that further examination would be desirable. From the extreme beauty of the neighbourhood, and the interest widely felt in the neighbouring well-known cave explored many years ago, the district seemed a very fitting place for an excursion by the Liverpool Field Naturalists' Club. The suggestion was made and acted upon, the excursion of the Club taking place, by the permission of Mrs. Williams Wynne, very shortly after. Mrs. Wynne kindly allowed the collection from the explored Bone Cave to be inspected at the Hall, where it was obligingly shown to the visitors, by the Rev. D. R. Thomas. This gentleman, at the request of Mr. H. F. Hall, subsequently obtained Mrs. Wynne's sanction for a few days' excavation to be made in the unexplored cavern, and on the 29th of June, Mr. Hall, Mr. Archer, and myself, aided by Mr. Thomas, commenced active operations. We employed two labourers to dig out the soil and wheel it to the mouth of the cave for close and careful examination. Mr. Archer and I continued hard at work for a week, but Mr. Hall, having an engagement, was compelled to leave at the end

of the second day. The week's labour resulted in the acquisition of a considerable number of bones and several teeth. The majority of the bones were in fragments, and scarcely a tooth was in sitû. Mr. Archer and Mr. Hall directed their attention more particularly to the bed forming the floor of the cave, while I undertook the determination of the bones. My duty has proved more serious than I had anticipated, from the trouble involved in procuring and cleaning skulls and skeletons of recent animals, with which to compare the bones and teeth that were dug up. Although the Osteological Collection in the Free Museum is probably only surpassed by the collections in London and at the Universities, it is richer in the rarer forms than in the more common species required for this purpose. This circumstance, and the heavy pressure of other duties, have greatly hindered me in the accomplishment of my task. In consequence I am only able on the present occasion to submit the determination of a portion of the bones obtained. These consist of fragments of lower jaw of badger; molar teeth, limb bones, and tip of horn of stag; molars of horse; a few canines and several molars of cave bear, and a fragment of what would appear to be the molar of rhinoceros.

ON THE DISCOVERY OF MAMMOTH REMAINS IN THE ISLAND OF PETIT ANSE, LOUISIANA.

By Dr. Hulse, of the U. S. of N. America.

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ABSTRACT

OF THE

PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

SESSION THE NINTH.

1867–68.

LIVERPOOL:

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ABSTRACT OF THE PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

SESSION NINTH.

OCTOBER 15TH, 1867.

The PRESIDENT (ROBERT A. ESKRIGGE, F.G.S.), in the Chair.

WILLIAM A. RICHARDSON, C.E., and the Rev. B. MARNER LLOYD were elected Ordinary Members.

The PRESIDENT read his

INAUGURAL ADDRESS.

IN resuming at the commencement of the ninth session of our Society the position in which your kindness has placed me, I shall ask your indulgence if I depart in some respects from the course which has generally been pursued by my predecessors in this chair. It has been customary, I believe, for the President, in his opening address, to review the proceedings of the Society during the foregoing session, and also to take a general retrospective survey of

the more recent progress of the science of geology, so as to note the more prominent of the new facts which have been brought to light, and the deductions arising therefrom.

In our published proceedings for last session, although they contain some valuable papers, there does not seem much to invite comment, except it be to remark upon the very large number of our members whose names are conspicuous by absence from its pages. Numerically our Society is probably stronger now than at any former period; but you will pardon me if I remark that there does seem to be a lack of that enthusiasm which is the mark of vigorous life, and which is so essential to its preservation. Of course, it could not be expected that, consisting as our Society does, almost entirely of amateurs, whose time is necessarily occupied chiefly with other pursuits, and who are able to devote only a brief leisure to scientific objects, the same fulness of research and maturity of knowledge should be exhibited as in the transactions of those metropolitan societies which include a very large number of men whose lives are devoted to science as a profession, and who have enjoyed the advantages of systematic and laborious special training. Nevertheless, I am convinced that if all our members would diligently avail themselves of the opportunities of observation which come within their reach, and would carefully register the phenomena of their own neighbourhood, with a view of bringing them under the notice of the Society, not only would our meetings possess for those who attend them a much livelier interest, but we should be gradually amassing a valuable store of geological facts which, in some appreciable though humble measure, might advance the progress of the science. I rejoice, therefore, in the knowledge that during this session we are to have submitted to us some important

matters connected with our local geology, which I have no doubt will give rise to considerable discussion, especially with regard to the so-called submarine forest beds of Dove Point and Leasowe, and the drift of the coasts of Cheshire and North Wales. As both these are subjects upon which all our members may easily inform themselves by personal observation, I trust we shall enlist a large number in their consideration.

Turning now to the science in general, there do not occur to me any very striking features in the history of discovery, nor in the literature of the last two years, calling for extensive notice. I shall therefore invite your attention to one small province alone in the wide field of geological research, and endeavour to condense the results of the labours of many workers into an essay towards a stratigraphical history of Great Britain in Palæozoic, and, if time permit, in Mesozoic ages.

The science of geology addresses itself to two objects—the one is to unfold the successive physical changes which our planet has undergone, and to recover, so far as may be, the records of the situations and extent of the oceans and continents of past epochs; the other to ascertain the nature of the organized creatures which lived during these successive ages. The latter is the domain of palæontology, the former that of physical geology.

Practically we find that these two departments can scarcely be studied separately, for they are so closely connected that each is continually required to assist the other. The palæontologist has to call in the physical geologist to account for some sudden change in the character of the remains of animal life found in beds closely contiguous, whilst the physical geologist has continually to avail himself of the results of palæontological inquiry to enable him to determine the age of beds he may be studying, in

relation to others in different geographical areas. And not only is this interdependence manifested as regards age and sequence, but the organic remains found in any stratum are often very good guides to the physical features which must have obtained during their life; the depth of the sea, the proximity to or distance from shore, the size of a continent, as shown by the mammalian remains, &c.; and on the other hand, the fineness or coarseness of sediment, its calcareous or other mineralogical character is frequently an index to the type of animal life to be met with.

Into the palæontological results of the science I do not intend to enter at all this evening; but I shall take for my text the geological map of Great Britain, and shall devote myself to the task of unfolding a few of those wonderful physical changes, by which, in the course of untold ages, its present highly complicated geological features have been produced. I must request that this be regarded simply as an essay towards the object in view. There is, doubtless, much to be learned before even one fully acquainted with the results of geological labour could write a complete history of the past; and there may also be, which is equally important for us to remember, much to unlearn, for our erroneous theories of causation often lead us to take perverse and mistaken views of facts.

One other explanatory word. I shall avail myself with the utmost freedom of the general run of geological knowledge, as embodied in the extensive literature of the science, and shall not deem it necessary to refer to all the authorities for the various facts adduced, nor, except perhaps in a few instances, for the theories referred to. To mention the original authorities in all cases would encumber my address with references, and, in many instances, facts have

become impressed upon my mind in the course of general study without my being aware from what special source they were derived.

Now, there are two ways of studying history—one is to begin from most recent times and work backward from facts best known to those more remote and uncertain, and when the records of the past become dim and untrustworthy, to use the indications of existing facts, such as the language, manners, laws, and customs of present races, to throw light upon and interpret the past; the other is to collect the traditions of most remote ages, and to decipher them first, and travel down the stream of time into ever clearer light and knowledge. We shall, to a certain extent, make use of both methods, for, whilst it will be necessary to avail ourselves of the knowledge of existing facts and the present order of nature to explain the phenomena of long past changes, we shall commence our historical labours in the farthest part of which we can find any tangible records, and ascend towards the present.

Of a beginning of things geology tells us nothing; our knowledge of time and succession is relative only. I shall not, therefore, dwell even for a moment upon the numerous theories of cosmogony which have been propounded. My first survey will date from the earliest known appearance of land, more or less consolidated, in the area we now call Great Britain.

And here I may remark, that there is, so far as I know, no area of equal size on the whole surface of our globe which presents such full data for an examination of past geological history as are written in the rocks of Great Britain; for we have, with few trifling exceptions, representatives of all known geological formations, and, owing to the highly inclined position, more especially of the older rocks, a greater thickness of strata is laid open for observa-

tion than is usually the case over areas one hundred times greater; in fact, it has been well said, we have a complete epitome of the geology of the world, and, as it were, a whole continent compressed into a small island. I may observe in passing, that to this completeness of development of geological structure may be traced much of Britain's commercial greatness.

The oldest land surface, then, in the British Isles, of which we have any knowledge, lies to the extreme north-west of Scotland, and embraces the Hebrides, and a narrow strip of the mainland, some ten to fifteen miles in breadth, from Cape Wrath to Gareloch, reappearing in some of the numerous islets with which the sea is studded as far south as Iona. The mineralogical character of the rock is a highly crystalline and much convoluted gneiss, and the most recent surveys have resulted in the correlation of these beds upon satisfactory grounds with the immensely thick series of deposits bordering the St. Lawrence, in Canada, which in lithological character they closely resemble. They are now, therefore, known by the name of Laurentian; and one of the most important features in connection with them is, that they strike in a direction almost at right angles to nearly all the newer deposits of our island, viz., N.W. to S.E., instead of N.E. and S.W., showing that the forces of upheaval at work in those distant ages when these rocks were first elevated to form dry land, acted upon different lines to most of those of later ages. The strike is well shown upon Sir R. Murchison's sketch map, near Loch Maree, where a band of limestone in the gneiss more or less persistent over a course of some ten miles, forms almost a right angle with the long limestone ridge intercalated in the micaceous and flaggy quartzose rocks which overlie the Cambrian sandstones, of which we shall presently have to speak. Even the

granites of this primeval land are evidently of more recent origin than the gneiss, for in the island of Lewis they are distinctly seen to traverse fissures in the gneiss, a plain proof that the latter was not derived from the degradation of the granite.

Although the limestone above referred to, as occurring in the gneiss, is held by some authorities to be in itself a proof of the existence of organic life at the time of its deposition, no distinct organic remains have yet been found in it in Scotland; but, as is well known to all of you, a similar limestone in Canada has yielded what is regarded by many of our best palæontologists as a fossil called Eozoon Canadense. The same form has also been found more recently in the rocks of Donegal and Galway, and upon this as well as lithological evidence these Irish rocks may be grouped with the beds in the N.W. of Scotland described above. Over what other areas in the British Isles the Laurentian sea extended it is impossible to say; but, most probably, the syenitic ridge of Charnwood Forest, in Leicestershire, whose strike is also N.W. and S.E., and the long range of the Malvern Hills, belong to the same great series. The absence of organic remains shuts us out from one ready mode of correlation; but whether the beds be absolutely contemporaneous or not, it is certain they *are all præ-Cambrian*, and separated from that formation by a very wide distance of time, for in all the instances above cited, Cambrian rocks lie upon the denuded edges of beds which had already suffered considerable metamorphism before the Cambrian was deposited; the proof of this in Scotland lies in the fact that the lowest superincumbent rocks contain pebbles of metamorphosed gneiss.

The first glimpse then that we obtain of our native land is in the shape of a group of small islands, rising out of the ocean, probably brought up by the same elevatory

force which raised into the foundation of a vast continent the long ridge of similar rocks in North America, stretching from the St. Lawrence far on towards the present shores of the North Pacific.

The highly metamorphic character of all these rocks, and the proof given above that this metamorphism was of very early occurrence, would seem to show that the forces which consolidate and metamorphose rocks were developed with much greater intensity then than now, and I cannot help attributing this to the comparative thinness of the earth's crust, and the much higher temperature which then prevailed from the radiation of internal heat. Excepting the much controverted Eozoon, we have no *proof* that either in the sea or on the land was there any living creature or plant; but all scientific experience ought to prevent our hasty conclusion that none existed, for we have almost daily to push back the limit of life, so that we begin to doubt whether there be indeed any portion of the universe strictly azoic.

The thickness of the Laurentian deposits in Great Britain is not yet ascertained, but in America they attain a thickness of 30,000 feet, separated into two *unconformable* divisions, and are overlaid by 18,000 feet of strata, termed the Huronian formation, of which, unless it be in the lower Cambrian, we have no representatives in this country. So that from the ruins of land of which we have no record, sediment was distributed over the ocean bed to the depth of 30,000 feet, consolidated, upheaved, denuded by atmospherical and marine agencies, again depressed, at least in part, and covered by 18,000 feet more of strata, which in their turn were elevated to form dry land. What an unfathomable vista of time does this open before us, and yet only the first foundation stones of our island home were then laid!

The next stage in our history is represented by the Cambrian formation, which is exhibited at the present surface in many parts of our island, and varies greatly in its lithological character. In the N.W. of Scotland it is first a conglomerate, derived evidently from the gneiss, passing into chocolate and brown sandstones, dipping S.S.E. at comparatively low angles. In the Longmynd and in the anticlinal of Merionethshire it consists chiefly of coarse grits, sandstones, and quartzites. At Llanberris it is a highly cleaved fine slate; in Anglesea, a much contorted gneiss and mica schist; at Charnwood, it is a roughly cleaved slate; in South Wales a thick series of conglomerates, sandstones, and slates; whilst in the Hollybush sandstone of the Malverns it has hardly undergone any metamorphism. The Cambrian also occurs in Ireland, in the counties of Wicklow, Wexford, and Dublin.

The general strike of the Cambrian is N.E. to S.W., though varying locally, and, viewed as a whole, the beds seem to fold over in a series of anticlinal ridges, which most likely spread over nearly the whole of the British area, though it is only here and there they are exposed by denudation of overlying rocks. Wherever its relation to the underlying rocks can be seen—as in Scotland, Charnwood, and Malvern—the Cambrian is either conglomeratic or contains pebbles evidently derived from older strata. The thickness is in Scotland 6,000 to 8,000 feet; in the Longmynd, no less than 20,000 to 25,000 feet; in Merionethshire it has been measured to 8,000 feet, but, as the bottom is nowhere visible, we cannot tell how much more. Towards Llanberris the beds seem to thin out, and are apparently not more than 5,000 feet thick.

Except in Scotland and in Anglesea, I am not aware that there is any unconformability between the Cambrian and next overlying rocks; we must therefore conceive

that whilst in the north of Scotland and the western part of Wales the Cambrian was elevated into dry land, the rest of the British area, except the few Laurentian islands indicated above, remained beneath the sea, until most of the lower Silurian strata had been deposited. During the deposition of the Cambrian rocks we have no evidence of great volcanic activity; for though these beds are disturbed and pierced by igneous rocks, the intrusions are, for the most part, of later date. There must have been strong currents to spread out over wide areas the coarse materials of which these massive rocks are composed, and the coarseness of sediment, as well as the extent of ripple-marked beds, would seem to indicate that the seas were not very deep.

We now come to that important series of formations grouped together under the name of the Silurian system, upon the physical history of which many volumes might be written, but it will be impossible to do more within the time at my disposal than to treat of them very generally. In Scotland rocks of lower Silurian age constitute the greater part of the present surface of the country, forming a series of synclinals and anticlinals, over the valleys of which extend the newer formations. The upper Silurian is very partially exhibited, and that chiefly in the south and southeastern portions of the country, and it is most probable that the northern extremity continued above water, whilst further south the land was submerged.

Travelling southward we find rocks of this age occupying a large dome-shaped tract of country in Cumberland and Westmoreland, so well known for the romantic scenery of our lake district, and extending into some of the valleys of Yorkshire and North Lancashire to the east. Wales, both north and south, consists largely of Silurian deposits, as well as the counties of Shropshire and Worcestershire; there are also a few tracts in the midland counties brought

up through newer deposits, and passing on to the extreme southwest we find lower Silurian strata in the headlands of Cornwall.

But we also possess positive evidence that the Silurian sea extended over a much wider area, for in a boring undertaken at Harwich, after passing through 1,000 feet, the base of the gault was found to rest upon a black slate apparently of Silurian age. Borings at Kentish Town and at Calais also give evidence of palæozoic rocks below the upper secondary formations, though their exact geological position could not be ascertained. The various subdivisions of the Silurian rocks contain almost every variety of lithological character, but they are chiefly mudstones or sandstones more or less metamorphosed into shales, slates, or quartzites, with a few extensive developments of limestone both in the upper and lower divisions. Both deep and shallow seas seem to be indicated, as well as in some places shore conditions. The lower Silurian period appears to have been one of great volcanic activity, the eras of the Llandeilo and Bala beds being marked by vast igneous outbursts, as is shown by the felspathic lavas of Cader Idris and Snowdon, in Wales, and the porphyritic slates and greenstones of the lake country, which probably approximate in age to the igneous rocks of Cader Idris.

Some of the subdivisions of this system appear to be very local in their extent, as for instance, the Tremadoc beds, which, although attaining a thickness of 2,000 or 3,000 feet, were until lately thought to extend only a few miles from the town of that name, and even now are only known for a short distance on both sides the Merioneth anticlinal, though they have been most eagerly sought for elsewhere, both in North and South Wales. The Lingula flags also, which have a much wider superficial area than the Tremadoc, thin out from 6,000 to 2,000 in a distance

from east to west of eleven miles, and are entirely wanting in Scotland.

Professor Ramsay enumerates no less than five stratigraphical breaks in the Silurian, which he considers to represent as many periods during which the sea bottom was raised to be dry land, and in his opinion, the length of time thus represented by blanks was quite as long as that of which the rocks afford tangible records. This inference is mainly supported by palæontological evidence. Whether the force of Professor Ramsay's reasoning be accepted or not with respect to the minor breaks between the Lingula flags and Tremadoc, and between the Tremadoc and Llandeilo (and I do not myself consider it conclusive), there can be no doubt that at the close of the lower Silurian period the area of the British Isles, or the greater portion of it, was elevated into dry land and underwent extensive denudation, probably in connection with a large part of the continent of Europe. The proofs of this are numerous both in the north and south. In many localities in South Wales the upper Llandovery rocks are seen to repose upon the upturned edges of the lower Silurian, Llandeilo, Caradoc, &c.; and in the Longmynd there is clear evidence that the upper Llandovery formerly extended right across the Cambrian hills. Again, near the town of Llandovery, at the mountain called Noeth Grug, a clear unconformability may be detected between the upper and lower formations of that age, marking this as the boundary line between the two epochs—a conclusion supported also by palæontological comparison.

It is to the interval between the two great Silurian epochs that Professor Ramsay attributes the contortion and first cleavage of the lower Silurian rocks of Wales and Shropshire, when above the slates of Llanberris and the grits of Harlech were piled the immense thicknesses of

Lingula flags, Llandeilo and Bala beds. In our present surface conformation we have, of course, only the last result of immense and oft-repeated denudations, no less than 25,000 feet having been removed from some districts in Wales. The Longmynd and Bala faults most likely belong, at least in part, to this period of disturbance, but the line of fracture once made, the throw may have increased gradually through various periods.

After the long interval represented by this upheaval and contortion, the country once more sunk beneath the ocean, and remained so during the deposition of the upper Silurian strata, which attain a total thickness, when fully developed, of about 6,000 feet. In Scotland, as already pointed out, the upper Silurian is very poorly represented; in the North of England the same is the case; and in both these northern localities there is an unconformable break between the upper Silurian and Old Red, whilst in South Wales and Shropshire the two latter formations are continuous without any stratigraphical break. We must therefore adopt one of two conclusions: either the northern portion of the island was above water during the greater part of the upper Silurian epoch, or else at its close it was again upheaved and denuded during the earlier Red Sandstone periods, whilst the southwestern portion of our area continued beneath the sea, though, owing to some alteration in the physical features of the land, the sediment with which the currents were charged was totally changed in character, and with this came a gradual but marked change in the organic life. The latter conclusion seems to be preferable, for considering the numerous patches of upper Silurian, both in the south of Scotland and in northern England, it is difficult to conceive how these could have been locally deposited, and the neighbouring tracts remain above water; and moreover, where newer deposits are found resting upon upper

Silurian in the north, there is distinct evidence of extensive denudation having intervened. During the upper Silurian periods there is little or no evidence of volcanic activity.

It is quite beyond my province to-night to trace the present and former extent of Silurian deposits beyond the British area; but when we take into consideration the immense tracts of country in all quarters of the globe, both in the northern and southern hemisphere, at the poles and in the tropics, which have been brought under geological survey, and over which these formations are found to be developed, presenting physical characters and fossils corresponding closely to and even identical with those of our own country, we are led to ask, where were the lands whence these immense series of deposits were derived?

Take what is generally called the primordial zone. Now, in North America, in Britain, in Scandinavia, in Bohemia, and in Russia, we find an almost identical fauna, with changes always succeeding each other in certain definite order, and mark you, *never recurrent;* so that if you present to the palæontologist the fossils of a certain zone from one of these localities, he will at once be able to parallel them with the corresponding zones in the others. Now, does this wide diffusion of nearly identical forms indicate that the seas were continuous contemporaneously over such vast areas, as would be the inference from the existence of similar fauna in modern times? If so, then must not the lands whence these thick deposits were derived also have formed broad continents, rising into lofty mountains, and traversed by mighty rivers? But it seems difficult, with our present knowledge of the almost universal diffusion of organic life, to conceive of such conditions without supposing the existence of the higher types of animal life, and of such we find no record.

It has occurred to me sometimes in pondering these

phenomena of palæozoic ages, that another explanation might be given, viz., that instead of vast continents and wide unbroken seas, the comparatively thin crust of the gradually cooling earth was constantly undulating, with a slow motion, so that the lands were not very high, nor the seas very deep; andthat land consolidating more rapidly then than now, the ocean bed of to-day over a certain area was ere long elevated to be the land whence fresh sediment was derived, and, after a comparatively short period, again submerged, so that the beds which, from their organic remains, we now correlate as contemporaneous, were not strictly so, but successive over different areas, and yet all within the period during which certain similar physical conditions obtained (and which period geologically we call short), so that their respective faunas retain a similar facies. The local character of some of our lower Silurian for mations already referred to would seem to confirm this hypothesis.

In the present state of our knowledge it seems impossible to arrive at any certainty upon these points, but I think we may safely conclude that the very wide diffusion of certain forms of animal life indicate the persistence of similar conditions over ocean tracts now supporting fauna widely different and whose physical features present the utmost diversity.

We must now pass on to the Old Red or Devonian period, which, though extensively developed in various parts of our islands, is as yet but imperfectly understood as regards the correlation of its different members, and is a favourite battle ground for rival theorists, so that I shall content myself with indicating its main physical features and some of the conditions which evidently prevailed during its deposition.

It may be asserted then, with tolerable confidence, that the broad tracts now occupied by the Old Red in Shropshire,

Hereford, Monmouth, and Brecon, with extensions through Carmarthen and Pembroke to Milford Haven, the whole of the South Wales coalfields, the British Channel and the north of Devon, with, most likely, a considerable area to the east and south of this, continued beneath the sea from the close of the Silurian until at least the commencement of the carboniferous epoch. This is attested by the fact, that over the district thus indicated, there is no stratigraphical break between the upper Silurian and Old Red, nor between the Old Red and the Carboniferous limestone, the whole forming one conformable series, separable only by lithological and palæontological peculiarities.

In Shropshire, along a section from the Ludlow formation to the Clee Hills, the thickness of Old Red is about 3,700 feet, whilst to the southwest the same series expands to not less than 10,000 feet without any physical break. I had the opportunity, in company with Mr. Morton, about two years since, of examining the line of junction between the upper Silurian and Old Red in the neighbourhood of Llandovery, towards the Fans of Carmarthen; at the same time also we traced the unconformity above alluded to between the upper and lower Llandovery.

In North Wales, and also through Lancashire and Cumberland to near the Scottish border, the land was most likely above water from the Silurian until nearly the close of the Red Sandstone epoch, because wherever we find deposits of the latter age at all, they are apparently only the uppermost beds of the series, and often only a thin band of red conglomerate. At Llangollen they may be seen as a richly ferruginous band below the Eglwsegle rocks. Near St. Asaph also the formation is represented in a highly interesting brook section, which I visited last year in the pleasant society of Messrs. Hall and Morton.

A conglomerate of large well-worn Silurian pebbles,

containing abundant fossils, marks the ancient shore line, whilst the eroded surface of the highly-inclined Silurian beds indicates plainly the lost interval. The strata dip at low angles, and though we had not time to measure the thickness of marly and flaggy beds, which here represent the Old Red, it was certainly not great.

A few small patches of Old Red near Kendal, Kirkby Lonsdale, and Ingleton present the same general features, and from thence up to the Scottish border occasional outliers give proof of its former northern extension, but it nowhere attains any considerable thickness.

In Scotland, where the succession has been laboriously studied by Mr. Geikie and Sir R. Murchison (from whose papers and maps most of the following information is derived), the present surface area of Old Red extends from the northeastern promontory of Caithness, down the coast to the town of Cromarty (rendered classical by the fruitful labours of the illustrious Hugh Miller), thence to Inverness, and about halfway along the borders of Loch Ness in a gradually tapering band; it also runs round the coast to Elgin. It is again met with to the south of the Grampians, extending from Stonehaven to Dumbarton on the Clyde, and finally, it occurs in considerable thickness, if not with large surface development, in the Pentland Hills and the neighbourhood of Lanark.

The labours of the survey have established a distinct triple division, with one if not two well-marked physical breaks, both in the north and south of Scotland. In Caithness we find the lower beds, again a conglomerate, resting upon granite and lower Silurian, and after a thick series of sandstone and flags, containing the well-marked ichthyolites so characteristic of the period: the whole are overlaid *unconformably* by an upper Red Sandstone, apparently belonging to the base of the Carboniferous system. Along the

line of the Pentland Hills, on the other hand, we find a conformable passage from upper Silurian to Old Red, with a development of the latter to the thickness of several thousand feet. These beds, as well as the underlying Silurian, are traversed by massive igneous dykes, and in some cases have been lifted into an almost vertical position *before* the upper part of the series, which graduates conformably into the Carboniferous, was deposited. In the very interesting address to the geological section of the British Association, at the recent meeting in Dundee, Mr. Geikie pointed out that the igneous rocks belonging to the Old Red in this part of Scotland attain a thickness of 5,000 feet, so that we have represented by this interesting break a long and troubled period of upheaval, volcanic disturbance, and renewed depression, the close of which probably corresponds to the time when the poorly developed Old Red beds of the north of England and Wales were deposited.

In Devon and Cornwall the relations of the beds are a subject of much controversy. It will be sufficient to observe that we have evidence that this tract was under water at two separate intervals between the Silurian and Carboniferous periods, and that whilst the thick limestones of Teignmouth and Torquay point to the existence of coral reefs of considerable extent, during the growth of which there must have been an absence locally of any strong sediment-bearing currents, the highly disturbed position of the beds further to the southwest, and their fragmentary character, indicate a similar period of volcanic activity to that which we have seen to obtain in Scotland. In Ireland the phenomena tally pretty closely with those of Scotland, one portion of the series connecting itself physically and palæontologically with the Silurian, and the other with the Carboniferous—the former portion presenting evidence of long continued volcanic activity.

We are now brought in ascending order to the great Carboniferous series, which both economically and geologically presents so many features of the highest interest. It includes, besides the coal measures proper, the mountain limestone, millstone grit, many bands of rich ironstone, and an immense thickness of sandstones, clays, and shales, all more or less impregnated with carbonaceous matter; hence the name applied to the group, or system, as it might well be called, from its importance and the peculiar features it displays.

The area occupied by the true coal measures is appropriately indicated on the map by a black shade; the subordinate members of the formation are coloured rather lighter, and the limestone and associated shales blue. A glance at the map shows that this series covers a large portion of the north and west of England and of south Scotland, but is entirely absent from the south and east. Now, if we had a complete geological sequence all over England, we should, of course, always find the Mountain Limestone resting upon the upper Old Red; but this, as you well know, is far from being the case. We have already noticed that in South Wales, as well as in parts of Scotland and England, the true succession is observed, but taking wide areas, the lowest beds of the Carboniferous group run transgressively across rocks belonging to all the older formations. In the vale of Lune they rest upon upper Silurian; in the valley of Horton, near Settle, upon lower Silurian (here the section is a most interesting one, the horizontal beds of limestone resting upon the highly inclined and cleaved slates); and again, in central England, at the northern extremity of Charnwood Forest, the coal measures are found resting upon rocks either Cambrian or præ-Cambrian. Such facts as these show the nett results of the denudation of the northern half of the island, which occurred before and during the Devonian period.

At present our coal measures are split up into a number of isolated fields. The great Scotch coalfield; lying in a trough which extends from the Frith of Forth to the Clyde, between ridges of older rocks, and was probably once connected along the eastern coast with the Durham field—the physical features of these two areas corresponding more closely than either of them does with the more southern ones—the fields of Lancashire, Yorkshire, Derbyshire, Staffordshire, North Wales and the midland counties, forming a second group; and the vast field of Glamorganshire, with the Forest of Dean constituting a third; with the latter should probably be associated the Culm measures of Devonshire.

Now, the question naturally arises, were not all these fields once connected, and only separated by upheaval and subsequent denudation? Referring to the map, we notice that a tract of millstone grit, which generally forms the base of the workable coal measures, and is often on this account designated by the miners "Farewell rock," stretches between the coalfields of Durham and Yorkshire, and forcibly suggests the conclusion that the higher beds were once continuous over it—the same facts obtain with regard to the area between the Lancashire and Derbyshire fields. The coal measures of Flintshire, again, have been proved up to and even below the Dee, and taken in connection with the outlier at Neston, it is now almost a certainty that they are continuous beneath the Wirral peninsula, the river Mersey, and Liverpool, and so connect themselves with the Lancashire beds. How far beneath the surface the coal lies it is impossible to say, for we know not the thickness of the red marl, nor whether the Permian beds exist there.

But without resting upon superficial indications, the minute researches of the Government geological surveyors tend to supply an affirmative answer to this question of the

former continuity of the coalfields, as regards at any rate, those of north and central England, and the same for the southern group, but that, in all probability, these two main coal areas were separated by a land barrier, stretching from the middle of Wales across central England in a northeasterly direction towards Scandinavia. The evidence that such a barrier existed during the deposition of the coal measures was first pointed out by Mr. Jukes, but has been worked out more fully by Mr. Hull. It consists briefly of the thinning out and deterioration of the beds, and their resting abruptly against rocks of much older date. At Atherstone, the Lickey, and in Charnwood Forest, as well as many other localities, these old rocks reach the surface, and are, most probably, only isolated portions of a ridge which formerly attained greater elevation. Possibly this same barrier may have been the cause of the Old Red deposits not extending continuously northwards. The greater part of Wales, including nearly all its more highly mountainous districts, was also above water, as well as the Silurian tract of the lakes, so that the probable area which the Carboniferous series originally occupied may be thus indicated on the map, say from Durham across to the coast, near Whitehaven, and seaward to the west, running round the lake district, and covering nearly all Lancashire, with parts of North Wales and Cheshire, most of Yorkshire, Derbyshire, Staffordshire, and parts of Shropshire, Warwick, and Leicester, running up as on the Clee Hills, south Staffordshire, &c., into the bays of the supposed "barrier."

To the south of the barrier the series extended in a wedge shape, broader to the west, and gradually tapering to the east.

I am indebted to Mr. Hull for most of the interesting facts which follow, bearing on the physical geology of the coal period. He points out, that beginning from the north

of Lancashire there is a gradual but persistent thinning out from N.W. to S.E. of all the sedimentary strata, including the millstone grit, the true coal measures, and the Yoredale series. The following figures are the results of the latest surveys, and are taken from Mr. Hull's paper, read at the Dundee meeting of the British Association.

	N. Lancashire.	S. Lancashire.	S. Staffordshire.	Leicester.
Coal measures....	8,260	7,630	6,000	2,500
Millstone series ..	5,500	2,500	1,000	50
Yoredale series ..	5,020	2,000	2,000	50
	18,780	12,130	9,000	2,600

I would ask you especially to notice in connection with what follows the remarkable thinning away of the gritty series—from 5,500 in Lancashire to 50 feet in Leicestershire.

Now, in South Wales a similar thinning occurs from west to east, the sedimentary deposits (according to the same authority) falling from 12,000 feet in Glamorgan to 3,200 feet in the Forest of Dean.

In the former case then, we conclude that the currents bearing sediment from which these beds were deposited came from the northwest, and consequently the land whence they were derived lay in that direction. In the case of South Wales the land lay to the west.

But there is another class of facts complementary to those just quoted which sustain the same conclusion.

Limestone, as we have already pointed out, is not strictly a sedimentary rock, but generally of organic origin, chiefly, in fact, made up of metamorphosed coral reefs. Now, we know that such reefs grow up in *tranquil* parts of the sea, free from currents bearing much sediment, which would injure if not destroy the polype life; we should expect, therefore, the limestone beds to be thickest furthest from the land in any given area of sea bottom, so that if the hypo-

thesis be correct that the land lay to the northwest of the coal area, we ought to find the greatest development of limestone to the south, and less and less as we proceed northwards, and this is exactly what we do find; for in Derbyshire the Mountain Limestone is *at least* 5,000 feet thick (probably more, the base being nowhere visible); in north Yorkshire it is 1,000, further north 600, and in Scotland is represented by mere bands.

It is a remarkable fact, attested by the careful state surveys made by order of the American Government, that on that continent the phenomena of the Carboniferous series are precisely similar in general characteristics, viz., a thinning out of the sedimentary strata towards the southwest, and a thickening towards the northeast, whilst as we approach the present coast line the sediments get coarser. We seem warranted then in concluding that during the Carboniferous era a large continent existed somewhere in the North Atlantic, and that whilst a southeasterly current brought from its detritus to spread over the British area, which was then sea bottom area, a southwesterly current carried similar sediment over portions of what is now North America.

What then may we suppose to have been the succession of events? At the close of the Old Red period, or near it, most of the southern part of Scotland, and those wide areas of northern and central England already indicated, were depressed beneath the sea level, the depression probably being greatest to the south. In this sea coral reefs sprang up, attaining their greatest development in what is now Derbyshire, and gradually losing their reef-like character to the north.

Probably this sea was nowhere very deep, and over its northwestern portions first, gradually creeping south, a series of muddy deposits was thrown down. Then came what must have been a strong current bearing a gritty

deposit evidently derived from the ruin of quartzose rocks, thickest towards the north, and dying away in Leicestershire. But during the deposition of these grits there must have been at least local elevations into dry land, for we find, especially in the north, thin beds of coal in the millstone grit. After these conditions had continued for ages, either the source of the grit became exhausted, or in some way the sediment borne by the current became finer, and about the same time the whole western and central portions of our island were raised into a flat, low plain, probably resembling the western coasts of Lancashire. In the warm, humid climate which then prevailed, a rankly luxuriant vegetation started into life, comprising ferns in great variety, some of them arborescent, cone-bearing trees of spongy texture and rapid growth, others allied to the palm and its congeners, pines, such as the araucaria, &c., with a dense undergrowth of club mosses, equiseta, &c., of gigantic size. Upon this new land, probably when still swampy, like the lagoons bordering the Mississippi, sported the first air-breathing reptile of whose existence we have any record.

Well, after this vegetation had flourished, perhaps for ages (it must have taken a dense growth for long periods to consolidate into a bed of coal five feet thick), it was destroyed probably by an irruption of the sea, caused by a subsidence of the land. Fresh beds of sand and mud were deposited to become the sandstone and shales of to-day, containing scattered fragments of the trees and plants which still existed upon the neighbouring land, and after this had continued as a shallow sea or bay (how many years or centuries we cannot guess), the same or nearly the same area was again elevated, and soon clothed with a fresh mantle of vegetation.

In some cases the trunks of the trees composing these old forests are found erect, and it is remarkable that nearly

every seam of coal has an underlying clay penetrated with rootlets. These facts appear to warrant the conclusion that the vegetable matter composing the coal beds grew on the spot in most cases (although I would by no means deny that there may be instances of coal seams formed from materials drifted probably into an inland or estuarine lake)—perhaps both modes of formation may have proceeded simultaneously.

This process of alternate elevation and depression, of growth and decay, appears to have gone on for ages, which the mind wearies to contemplate, until at length some great change in the physical conditions of very large portions of the globe took place, which brought to a close the Carboniferous period, and was accompanied over our area by considerable elevation. I may just, in passing, draw attention to the fact of the identity of the vegetation of the Carboniferous period, whether found in Nova Scotia, Australia, or the islands of the North Pacific, with that of our own strata of this age, proving to my mind that even near the close of the palæozoic cycle, the climatal conditions were still very similar in the most opposite latitudes.

I omitted to point out in its appropriate place that the lower coal measures of Scotland were most likely contemporaneous with our Mountain Limestone, there represented, as above stated, by thin bands only; so that these are the oldest coal seams of the British islands.

At the close of the Carboniferous period we are met by another break in the record afforded by the stratified deposits, indicating that a considerable interval occurred between it and the Permian—for the latter nearly always overlies the former with marked uncomformability, showing that the land had been upheaved and denuded. To sustain this stratigraphical evidence of a break we have also that of palæontology, which discovers a decided change in the character of the life remains entombed in the two formations.

During this interval, unrepresented stratigraphically, the great central axis of England—at any rate in the north—appears to have uplifted into a broad arch, and in the upheaval some of the higher beds of the Carboniferous series were broken and carried away, so that we now see the lower beds exposed in the centre, northwards from Derbyshire to Durham, whilst the higher ones lie on the flanks of the arch.

We cannot tell what were at this period the exact boundaries of land and sea, as the Permian volume of nature's rocky library is but a defaced and tattered fragment. Most likely deposits of this age formerly extended over wide areas which now show no trace of them, as we know that another break more complete than any yet treated of occurs at the close of the Permian period, and was accompanied by vast denudation.

I think, however, we have sufficient evidence to conclude that the greater part of Wales, north and south, the Lake district, the Pennine chain, and the whole, or nearly the whole, of Scotland were above water. What we have spoken of as the "barrier" between the northern and southern coalfields, most probably still existed as dry land, and attained a greater altitude from the elevation of the whole country. There is also no evidence of the extension of Permian deposits, and, consequently, Permian seas, over the south of England, unless, as I half suspect, some of the so-called Triassic sandstones and conglomerates of South Devon prove of this age.

Turning from negative to positive evidence, we see from the map that the Permian sea certainly extended down both sides of the Pennine chain, although we have now only fragments of the deposits it left. It ran round the Lake district, which would appear in it as a mountainous island, and extended past Carlisle over portions of the southwestern

counties of Scotland. It must also have covered most of the midland counties of England, and large portions, if not the whole, of South Lancashire and Cheshire, now denuded or covered afresh by Triassic deposits.

The general character of the Permian rocks is a ferruginous or gypseous marl, sometimes saliferous, with bands of magnesian limestone, generally impure, and sometimes, as in Durham, assuming most extraordinary concretions. The total thickness is about 1,000 feet, probably more. But there is another series of beds which, from its stratigraphical position, must be referred to this period, which presents some striking peculiarities, and has given rise to very interesting speculations. It consists of breccia, of which the matrix is a marly paste containing boulders, derived chiefly from either igneous or Cambro-silurian rocks, occurring not as rolled pebbles, but mostly either angular or subangular.

This breccia extends at intervals round the coalfields of North and South Staffordshire, Coalbrookdale, Tamworth, and the Forest of the Wyre, and rests with marked unconformability upon the Silurians of the Malvern and Abberley Hills. In vol. xi of the Q. J. Geol. Society, Professor Ramsay gives a detailed description of numerous sections, and, from the lithological character of the rocks of which the breccia is composed, he concludes that many of them must have travelled a distance of twenty or thirty miles, being derived chiefly from the neighbourhood of the Longmynd; and as there are fragments weighing more than half a ton, they can scarcely have been transported this distance by water alone.

We seem to know only one natural agent capable of removing blocks of such magnitude so far from the parent rock, and that is ice, either as glaciers or bergs; and Professor Ramsay unhesitatingly concludes that this was the

agent employed, and asserts that some, if not many, of the stones bear scratches and grooves similar to those so well recognised in our boulder clay as the result of glacial action.

According to this theory these brecciated beds are the moraines of ancient glaciers which came down from the high lands of the "barrier," and, possibly, also from some of the higher valleys of the Pennine chain. This hypothesis by no means necessitates an arctic climate, as we see from the Alps; and I see nothing in the fact of its succeeding to a warm period like the Carboniferous to invalidate its probability, for, in the comparatively recent history of our island, we have traces of transitions quite as violent.

During the spring of this year I took an opportunity of examining for myself one of these patches, occurring a few miles south of Birmingham. A good section is exposed by a deep road cutting, near Northfield. I should unhesitatingly assign nearly all the fragments of rock I saw to either igneous origin or Cambro-silurian age, a large proportion being unfossiliferous quartzites—some ribboned slate—but the majority were an altered sandstone, apparently of Caradoc or Llandovery age, charged most abundantly with characteristic fossils. Many of the stones are certainly quite angular, but mostly subangular, and some more or less rounded, though very far from being rolled pebbles. I did not succeed in finding any grooved or scratched, but the nature of most of the rocks was not such as easily to retain such markings. Many of the fragments are two feet in diameter, and *if they really can be satisfactorily proved to have come from the flanks of the Longmynd*, my own conviction is that no natural transporting agent can have brought them to their present position but ice.

The whole theory hangs on this point; and I must confess that to my mind there is a suspiciously strong lithological resemblance between many of the fragments and

the altered Llandovery sandstone of the Lickey Hills (within a distance from the section in question of not more than two or three miles), except that the latter is, so far as I saw, destitute of fossils. I only saw, however, part of the range, and I believe in other portions it is fossiliferous.

Professor Ramsay argues, from the stratigraphical relation which the Permian marls, capped with the breccia, occupy to the Lickey quartzite, that the latter must have been deeply covered by the prolongation of the former beds; and if this were so, of course the breccia could not be derived from that source. Without venturing to dispute so great an authority, it occurred to me whilst on the spot, and is confirmed by a subsequent examination of the sections, that this outlier of Llandovery, evidently the result of violent upthrust—for it is either bounded by two faults, or else thrown into a very sharp anticlinal—may have been very much higher during this later Permian period, nay, *almost certainly was*, for it must have suffered great denudation, along with all the other palæozoic rocks, during the upheaval which preceded the deposition of the trias. Now, if this rock were then at the surface, we have at once a near locality for many of the fragments referred to. There may, however, be other rocks which can be proved to come from the Longmynd; upon this my inexperience will not permit me to express an opinion. The question involved is one in which I feel a great interest, and I hope to devote some future leisure to its further investigation. If these be glacial moraines, they must be referred to the close of the Permian epoch, or rather to the interval between that and the Triassic. Then, as we know, vast changes of level, accompanied by immense denudations, occurred, not only in Britain but throughout Europe. The Pennine chain was further uplifted, and probably the coal measures much faulted, for many of the dislocations

do not extend through the overlying Trias sandstone. Immense portions, also, both of the Carboniferous formation, and the more recently-deposited Permian, were carried away. In the Vale of Clitheroe Mr. Hull calculates that not less than 20,000 feet of strata were denuded before the Trias was deposited.

This important and wide-spread break appropriately closes the palæozoic cycle, and when next we meet with stratified deposits a radical change seems to have come over the fauna preserved therein, bringing the types of organic life into closer resemblance with those of more recent times. It is as though in the history of some nation the record of one or more centuries had been lost, so that the student could only guess the nature of the events which had transpired in the interval by the effects produced on the national character, by the changes in its customs, mode of government, and its advance or retrogression in the scale of civilisation; so, as geologists, we know that the break represents vast ages, because we see that certain forms of life have disappeared and given place to others widely different, and also because of the evidence afforded by physical dislocations.

Into the Mesozoic records, which commence with the Trias, I had much wished to enter, at least as far as the era of the Wealden, but I dare not trespass longer upon your patience, and must reserve the rest for some future occasion.

I have not thought it necessary to dwell at any length upon the proofs of the incalculable ages required for the stupendous series of changes we have attempted to chronicle; for there is no controversy amongst geologists on this point, now that we have once escaped the supposed necessity of compressing all our planetary records into some 6,000 years. And why, I would ask, should the countless æons revealed to us by geology stagger our faith more than the

fathomless space and infinite cycles of the astronomer? Let us not make the mistake of measuring time by our finite earthly lives: it is God's world of which we speak—God who has eternity for his sphere of action.

Above all, let us not fall into the fatal error of shutting God out from the universe which he has created. All science of the present day, whether geology, astronomy, chemistry, or that which treats of those imponderable forces to which we give the names of electricity, magnetism, and the like, seems to proclaim that nature is one vast whole, divided only by us mortals because of our weakness and ignorance. *Unity of design* runs through the whole, and not only so, but *unity of force;* for the most evident and remarkable tendency of modern scientific research is to prove that all the various so-called "forces of nature" are only different modes of manifestation of one central and supreme force.

To my mind this unity, alike of design and of force, points, with unerring finger, up to one Designer and one efficient source of power—

> "That God, who ever lives and loves,—
> One God, one law, one element;
> And one far off divine event
> To which the whole creation moves."

NOVEMBER 12TH, 1867.

THE PRESIDENT, ROBERT A. ESKRIGGE, F.G.S., in the Chair.

DR. RICKETTS exhibited the minute and rare Star-fish *Protaster ? Salteri*, Forbes; and *Palæaster sp.*; the latter cannot be referred to any of the species described by Mr. Salter in Professor Ramsay's "Geology of North Wales."

Both were found by him close together, a little N.E. of the oval patch of Bala Limestone above Glyn-bach, east of Bala lake, where the dip is marked 40° on the geological map.

The following communications were read:

ON THE GEOLOGY OF THE DISTRICT OF CREUDDYN.

By Hugh F. Hall, F.G.S.

PAPER I.—ON THE DRIFT.

It is my intention, with the permission of the Society, from time to time to bring before you my observations on the geology of the district of Creuddyn.

This district embraces the peninsula of which the mass of Mountain Limestone called the Great Ormes Head forms the westward boundary seaward, and includes the Little Ormes Head—the hills of Maelgwyn and Gloddaeth, and the volcanic rocks of Bryngosol and Dyganwy, taking in the coast eastward as far as Colwyn Head, and bounded on the south by Conway Bay, the River Conway, and the Silurian hills that enclose the coast valleys which lie towards the northern boundary, the sea. Its whole extent is only about nine miles by four, but it embraces a very interesting series of beds, from the most recent to the Silurian, which it will be my endeavour to describe in the papers I propose.

It would probably be most fitting to begin either with the newest or the oldest beds; but having last year brought under your notice some observations on the Drift of Holderness, and my attention being most engrossed with that member of the geological system, I think it best on the whole to lay before you at once the sections that are found in Creuddyn of that interesting series of beds, even at the risk of a charge of want of order.

Here, as in Holderness, it is to coast sections that we are principally indebted for our knowledge of these beds, which at one time must have been the leading feature of its geological interest, as they have evidently not only filled the valleys below, but, as I shall have occasion to show, have covered the tops of the highest land in the district under consideration.

The following are the principal sections found in this district, which I have lettered so as to show the corresponding beds in each:—

GOGARTH.

D.—10 to 12 feet tough red clay, without many stones.

F.—30 to 50 feet of hard, gritty, dark brown clay, full of scratched boulders, and with much chert.

LITTLE ORME—*West side.*

D.—About 20 feet light red clay.

E.—15 to 20 feet pebble conglomerate—upper part sometimes consolidated into a bed of sand rock.

F.—About 50 feet dark grey clay—full of Silurian pebbles, ice-scratched, and masses of scratched Mountain Limestone, also angular fragments of chert.

LITTLE ORME—*East side.*

C.—Clayey sand, about 5 feet.

D.—About 30 feet red clay, with few pebbles.

E.—About 13 feet sands and gravels.

E 2.—About 20 feet—denudation bed of *stratified* grey clay, with ice-scratched pebbles sparsely distributed.

F.—About 10 to 40 feet dark grey clay seen in bosses, full of scratched Silurian and other boulders, fragments, and pebbles.

G.—3 to 5 feet Mountain Limestone rubble.

H.—Bedded Mountain Limestone.

Dyganwy.

A.—Blown sand.

B.—6 inches to 1 foot blue black clay without pebbles.

F.—About 18 feet (above high water) grey and black clay, full of ice-scratched boulders of Silurian and other rocks, and subangular fragments Mountain Limestone.

Rhos.

C.—2 to 3 feet clayey sand.

D.—18 to 20 feet red clay.

E.—About 2 feet sands and gravels.

F.—About 40 feet (including shore) grey clay, full of ice-scratched boulders and fragments.

Colwyn.

C.—About 50 feet (in ballast pit) sands and gravels.

D.—About 30 feet red clay.

F.—Blue clay, with ice-scratched pebbles, seen only in patches on shore, evidently tops of bosses now under denudation along with the red clay D which lies between.

Llandulas.

C.—About 20 feet sands and gravels.

D.—About 30 feet brown clay, with few pebbles.

F.—About 150 feet (at Colwyn Head), and rising in bosses along the shore, red clay, full of scratched pebbles.

We have then for our consideration seven sections, viz., Gogarth Section, west side of the Little Orme, east side of the Little Orme, and those at Rhos, Dyganwy, Colwyn, and Llandulas, from all which we derive a succession of beds as follows:—

General Section.

Beginning at the base, we find at the Little Orme—east side—the lowest bed is—

H.—The bedded Mountain Limestone.

G.—In same section 3 to 5 feet of Mountain Limestone rubble. None of the other sections go as low as this; but the rubble is most probably to be explained by the action of frost during the early part of the glacial period, breaking up the surface into fragments, which in this sheltered corner have not been carried away by the ice sheet which has produced the overlying

F.—Dark grey clay, which is the same as the base beds No. 2 at Gogarth, No. 4 Rhos, No. 3 West side Little Orme, No. 3 Dyganwy, No. 3 Colwyn, and No. 3 Llandulas; No. 5 Little Orme, east side: this bed has been denuded, and we have in the Little Orme, east side, one of the beds of denudation, viz.:

E 2.—Grey stratified clay, including within it patches of gravels and sands.

E.—The sands and gravels above this bed are, No. 3 East side Little Orme, No. 3 Rhos, No. 2 West side Little Orme.

D.—Red clay—No. 2 East side Little Orme, No. 2 Rhos, No. 1 Gogarth, No. 1 West side Little Orme, No. 2 Colwyn, No. 2, Llandulas.

C.—Sands and gravels, very largely developed in No. 1 Colwyn and No. 1 Llandulas, and also seen probably in No. 1 east side Little Orme and No. 1 Rhos. These two latter, however, may possibly be blown sand, as No. 1 Dyganwy.

B.—No. 2 Dyganwy; blue black clay, without pebbles, the result of exposure to a second denudation of the underlying grey and black clay, with ice-scratched pebbles, which is overlain by

A.—Blown sand dunes in No. 1 Dyganwy section.

Of the divisions H and G sufficient has been said under the remarks in the General Section. The other beds deserve fuller notice.

The beds F, I regard as the result of the grinding down of the subjacent strata by land ice, which at this period must have covered the whole of the land down to the water's edge, the *true glacial period.*

The evidence of this is found in the character of the beds themselves. Thus at Rhos the whole of the shore is covered thickly with pebbles of all sizes, from gravel to boulders several feet in diameter. These evidently cannot have been derived from the red clay D, which contains neither the quantity of pebbles requisite to form such a mass, nor pebbles of the size seen on it. Noting this fact led me to examine the shore itself, especially near low water level, and a careful search enabled me to dig up here and there, where the pebbly covering was thinner than usual, patches of stiff dark grey clay, full of pebbles imbedded in it of a character quite similar to the loose ones rolling on the shore. The greater number of these pebbles are slate, and those that are taken out of the clay itself are invariably ice-scratched, even to the smallest fragments. I should think I tried not less than one hundred, to get one that was not ice-scratched, without success. The surfaces that are exposed to the action of the sea and the rolling of the loose stones of the smaller pebbles, have lost the ice-marking; but even these show the scratchings on the side that has been protected by the enclosing clay. And we have here an instructive lesson as to the time that is required in a stiff clay like this to dissolve and wear away its surface by the action of the waves, when on a small pebble, not a quarter of an inch thick, the upper side will have entirely lost all traces of glacial action, while the lower imbedded side still retains them. Ten feet below high water

mark and under, there are many very large blocks of Mountain Limestone, greenstone, and volcanic grits, three, four, and five feet in diameter, which in many instances still show ice-grooving and smoothing, their greater size allowing deeper cutting than in small hand pebbles. The base of many of these still remains imbedded in this grey clay, evidencing the source from which they are derived.

This clay rises in the cliff in a boss, the position it occupies being distinctly marked, even at a distance, by the enormous boulders and huge limestone fragments which at such parts of the cliff strew the shore up its very base. Between Rhos and east side of Little Orme this clay continues to rise in bosses in the cliff, thus clearly evidencing a denuded surface, and consequent *unconformability* to the overlying beds. The character of the matrix and the pebbles contained in this bed are very much the same at Little Orme—east side—as at Rhos, the new features being a number of boulders of Old Red Sandstone, schist, and Cambrian conglomerate. This bed on the west side Little Orme is principally distinguished from that on the east by containing a large quantity of angular fragments of chert exactly similar to those found in Wyddfyd and Nantygamar porcelain clay beds described by Mr. Maw. I found several large slabs, two inches thick, and occasionally very white and sandy. The presence of chert is common to this section and that at Gogarth, but in other respects they are very different.

On the shore at Gogarth the clay (which can be dug between the boulders) is very stiff, being wet by the tide, but in the cliff it is hard and compact, more so than many sandstone rocks. It varies very much in its constituent parts, in some places being dark brown, in others grey in colour; but everywhere it is very gritty and sandy, and is full of scratched pebbles, with many fragments of chert.

On the face of the cliffs are to be seen numerous great boulders of greenstone, trap, slate, and Old Red Sandstone, and also subangular and angular masses of Mountain Limestone. Slate pebbles are not very common in this bed, as in those at the Little Orme, Rhos, and Colwyn, and even at Dyganwy—the angular chert fragments are probably the most characteristic. The boulders lying on the shore are frequently of very great size, and some of the Mountain Limestone fragments were fully twelve feet long; some of the greenstone and slate being from six to seven feet long. Those which have recently fallen from the cliffs, and lie nearly at high water level, almost all show ice grooves and scratches, and many of those also which have long been exposed to the tide and weather, showing that they must originally have been very deep. The planed surfaces are well marked on many of the masses and boulders, even of those which have lost their scratches through exposure—some showing a marked contrast between the smooth planed side and the rough broken surface on which the ice has not acted. Huge masses of conglomerate are occasionally to be found among the shore boulders, apparently derived from a local deposit visible in the cliff for from thirty to forty yards. On the top of this bed lies a seam of great boulders and masses of Mountain Limestone, trap, greenstone, slate, and Old Red Sandstone, probably left when the denudation of its upper surface had washed away the surrounding clay.

At Castell Tremlyd, Dyganwy, we find a low cliff about twenty feet high at utmost of greyish and black clay full of boulders, some six to twelve feet in diameter. The shore which hitherto has been entirely sand, opposite this point to far below low water shows these great masses everywhere, composed of greenstone, volcanic ash, conglomerates, and slate, all deeply striated and finely polished. This, though

a small one, is decidedly the best section for the observation of ice-markings—subangular masses of Mountain Limestone and angular fragments of volcanic ash, of which the hills of Bryngosol and Dyganwy, which lie immediately behind, are composed, are also plentiful. The black matrix and smaller fragments have evidently been chiefly derived from the grinding down of the slate, which is to be seen in the farm road of Maesdu. The largest boulders and the greatest quantity of pebbles are at the west extremity of the cliff—becoming fewer and smaller to the eastern end, where also the clayey matrix changes from black to a dull brown, the natural result of the change from slate to the lighter coloured ashbeds. A diligent search for shells in this bed was fruitless.

This bed has probably at one time occupied all the valleys, and even covered the mountain tops, as I found, at a height of at least 400 feet on the Great Orme, a boulder of greenstone, which most likely was derived from this formation. At the close of the glacial period, however, it must have been exposed to very considerable denudation, and now it is entirely removed from many of the valleys and the mountain tops. It has then been sunk below the sea level for a considerable depth, certainly several hundred feet, to enable the deposition of the bed

E 2.—Stratified grey clay, which is clearly a denudation bed, and is most probably of the same age as the beds E. It shows ripple and rain marks where the layers have opened by weathering.

E.—These are the same wherever seen, viz., irregular and false-bedded sands and gravels. Patches of these are contained in the E 2 bed. A patch of about five feet thick of *green*-coloured sand was to be seen in Little Orme, east side section, lying above the red and yellow sands and gravels, and

with thick beds of red clay, false-bedded both with it and the yellow sands below. It occasionally hardens into a thin bed of conglomerate, forming a marked division on the cliff face above the red clay; and on the west side Little Orme the whole bed is cemented together by carbonate of lime forming a hard conglomerate, masses of which are found on the shore twelve to twenty feet in diameter. The upper portion is composed of finer pebbles and sand, and forms a thin band of hard rock. It is noticeable that both these beds and the F beds are chiefly and best developed where they rest against the ancient Mountain Limestone cliffs, which have protected them against the forces which have denuded the valleys lying between.

After the shore condition evidenced by the lastnamed beds had ceased, through the deepening of the water over the old land surface, a deposit of

D.—Red clay, *which is everywhere of one character*, has been brought down by currents, bearing icebergs and icefloes, from the more northern regions of Ireland, Cumberland, and Scotland, which probably from its higher lands (as Mr. Searles V. Wood, Jun., suggests, would remain as islands when the more southern portions of what now forms England had been wholly submerged) still sent down glaciers to the sea. The uniformity of this deposit, the paucity of pebbles compared with the F beds, the scarcity especially of scratched pebbles, which when found would be derived from the icebergs, and the fact that it contains marine shells (as does also the E gravel bed), all show that it has been formed under very different circumstances from the glacial F beds, and at a time when glacial conditions were

modified by a warmer and more genial climate. The denudation to which the F beds have evidently been exposed before the deposition of these later beds, seems to me to necessitate this latter conclusion. When dry it breaks in cubes. It has much fewer pebbles in its upper portion than in the lower.

The relative position of land and water was again altered by the elevation of the whole of the beds already considered, during which the

C—Gravel and sands were deposited. These are best illustrated by the great ballast pit at Colwyn, the existence of which is explainable by its being nearly the centre of a great valley of denudation in the red clay, and to the recess of the shore there between the hills of Bryn Earian and Colwyn Head, the current passing eastward from one point to the other not having sufficient power to remove the pebbles once rolled up by the breaking waves in this quiet retreat. Thus they have accumulated age after age, until they attained the enormous thickness which is still seen, even after the denudation which is now going on must have carried away a considerable portion of them.

B.—The last point I have to notice is the small deposit of blue black clay without pebbles—B, Dyganwy Section. That the underlying F bed was covered with the red clay which is found both eastwards and westwards of this point, I think there can be no doubt—indeed, I conceive the red clay to have covered the whole district in one great sheet from end to end. This must have been entirely denuded, and the black clay exposed to a *second* denudation, which has resulted in the thin bed above referred

to. The ages that must have been occupied in the series of changes I have detailed to you I make no attempt to compute, but that they have been very great is beyond a question.

Such is the sequence of beds. The points to which I would draw your special attention are—

First—That *colour* is no criterion for deciding as to the F bed in the General Section, the Gogarth Section being in places dark brown, in others grey—the Dyganwy Section almost black—the east and wide sides Little Orme dark grey—the Rhos Section lighter grey—Colwyn shore blue, and Llandulas red brown; in fact, the colour depends altogether upon the *materials of which the rocks in the vicinity are composed.* This leads to the

Second point, which is, that the materials of which this clay is composed are always those which are found in the *immediate neighbourhood*, and even the large boulders can generally be traced to no great distance. Thus the Gogarth clay is evidently the result of the grinding down of the mica schists and limestones of Anglesea, and probably the millstone grit, which has been entirely denuded from the district, the greenstone, trap, slate, and Old Red Sandstone boulders found in it being all traceable to Anglesea as their source. I may here remark that this clay on the opposite shore of Anglesea shows the same composition as at the Orme, except that it contains numerous schist pebbles, which are wanting at the Orme, being probably ground entirely down before reaching that point.

The clay east and west of the Little Orme and at Rhos shows the result of the passage of the ice over the Mountain Limestone and Silurian beds, the latter supplying the adhesive material which makes this clay so much stiffer, and the small slate fragments which characterise it in these places. Again, at Dyganwy the black clay is from the

underlying slates, and the greenstone, slate, and volcanic rock boulders are easily traceable to the hills between Conway and Bangor, the greater paucity of the pebbles at the east end of the section being due to the main course of the ice being through the valley nearer the Great Orme, its course being somewhat retarded eastwards by the Bryn-gosol and Dyganwy hills, probably turning part of it through the valley of the Conway towards Abergonol and Colwyn. At Llandulas the reddish brown is due to the denudation of the Old Red Sandstone, which is still found at some distance inland, many large boulders of which can be seen on the shore.

Third—I conceive this clay to be the result of the disintegration by the pressure and passage of land ice covering the whole district, and I would confine the term "boulder clay" to this bed alone, believing it to be the *only true glacial clay.*

Fourth—This clay is invariably denuded, the bosses rising all along the shore showing this distinctly. The Dyganwy Section is a good example of a boss, and the sections on the Great and Little Orme, where the cliffs rise on a slope against the rock, as evidently show the effects of denudation.

Fifth—The red clay, which is invariable in colour and constituents in all the sections, does not possess, to my mind, the evidences of a glacial condition of the land such as obtained during the period of the F bed—the uniformity of the material, the scarcity of scratched pebbles and of boulders evidence that it has been derived from a much greater distance, and I conceive it to be probably the result of extensive denudation in much more northern regions after the climate has become more temperate in North Wales, spread over a sea bottom by currents, the scratched pebbles and boulders sometimes found in it being deposited

by melting or stranded icebergs. That it is a marine deposit its organic remains clearly show, and the shells spoken of at the height of 1300 feet on Moel Tryfaen probably belong to this deposit, when the high peaks of Snowdonia would, like those of the Lake district, remain exposed as islands when the valleys formed the channels of the sea.

It is here the proper place to give the sections of a well and an adit made in the valley immediately under the east cliff of the Great Orme, as given me by Mr. Thomas Jones, of Frondeg, the worthy overseer of the Copper Mines lately worked in the Ormes Head by Colonel Wynne, of Cefn. The well is in Church Walks behind the Royal Hotel, its surface being forty feet above sea level.

The red clay with pebbles was passed through at a depth of fifty-eight feet, and they found water after going through thirty feet more of loose debris of Mountain Limestone. A level driven just above this well for 150 yards into the Mountain Limestone rock for the purpose of trying for copper, and which is now used as a well for Brook's Victoria Inn on the Old Road, showed that the red clay rests against the limestone cliff at a distance of fourteen yards westward of the Royal Hotel well. The rubble below the red clay is evidently the talus formed by the limestone against the cliff before the red clay was deposited. It would be interesting to know whether the F beds No. 4 lie below this talus, as their absence below the red clay appears to me to be an additional evidence of the unconformability of these two deposits, the talus having formed during the period of subaërial elevation which caused the denudation of the grey clay. Mr. Jones informed me, in answer to an inquiry, that the clay is deepest farthest from the cliff, and the debris soonest reached near the cliff, being exactly what would be the case, on my supposition that it is an ancient talus. At

Ty Gwyn Mine, the perpendicular shaft passed through this loose angular debris, and in it were found periwinkle shells at a depth of several yards below present high water level. Below this debris they passed through sixty feet of *shale* without reaching the bottom. In the level which was run into the New Mine from the Conway shore, they cut first horizontally through thirty to forty yards of red clay, succeeded by about twenty yards of black gravel, with many shells (the Welsh names of which I could not understand or get an interpreter for at the time), and then through shale (called Killas by Mr. Jones) so soft that the pressure above broke the strongest timber in pushing its way into the open cutting, which eventually had to be walled round to secure its remaining open. After fifty yards they found rock above, the sides and bottom still remaining shale, but in about ten yards more the rock was lost again, until it was met sixty yards further on like a wall. I could not find whether this shale contained pebbles, or I think we might in that case conclude that in this horizontal cutting we had again evidence of red clay overlying the pebble beds, and they again lying on the grey clay; but without more positive information I should hardly like to do more than suggest this as a possibility.

Near Dyganwy itself is a particularly interesting spot, where the bedded slate is seen overlain by its crushed fragments, in which several huge boulders, many feet in diameter, have partly buried themselves. Now these slate fragments are not ice-scratched, being the result of the crushing and grinding power of the vast sheet of ice that has enveloped the whole district; but similar fragments, those which from time to time have been in contact with the ice itself, and become imbedded in it, and carried eastward by its motive power, we find left ice-marked in the beds we have described between the Little Orme and Rhos, having been scored by

attrition with each other and the ground over which they passed in the slow movement down the valley from Conway to Abergonol.

And that this is no imaginary picture, let me ask your attention for a moment to a section of a quarry just behind Towyn, which is worked for building stone. The slope of the hill is from the west, eastward, and the quarry is cut into the side of it, and shows beds of slate lying almost perpendicularly, thus exposing their upturned edges at the surface. Beneath three or four feet of loose broken rubble, these beds are seen to bend almost at right angles towards the east, the slate which in the lower parts of the quarry is in solid strata several feet in thickness, being broken into small fragments after it is bent and approaches the surface. Now what can we conceive to have caused this except some energy acting with quiet yet irresistible power in one direction? It is no puzzling series of distortions bending the rock in every direction, but one simple yet great curve, which requires for its explanation one simple but mighty force. And that the ice-sheet requisite to make this Titanic crusher has lain upon and gradually gravitated from the higher to the lower levels, is proved by the boulders which are still to be found lying on the rock surface, although the drift beds themselves have been almost entirely denuded.

I say almost entirely, for these same quarries exhibit where two faults have pushed up some beds above others, leaving an irregularity of surface, small remnants of the sand and gravel beds E, which are easily distinguishable from the blown sands above, not only by the pebbles contained in them, but by a bed of black vegetable earth one foot or eighteen inches thick dividing them. One of these remnants of the pebble beds is 220 feet above high water by the aneroid barometer.

THE SUCCESSION OF THE STRATA IN THE CHURCH STRETTON DISTRICT.

By Charles Ricketts, M.D., F.G.S.

As in the neighbourhood of Church Stretton the strata dip, always at a high angle, continuously towards the west for the distance of eight miles, from the lowest portion of the Cambrian formation to where the upper Llandeilo beds are covered by the Wenlock shale, it is evident that, taking the average angle of the dip to be 60°, there must have been a subsidence during the process of deposition of at least seven miles, and it follows that, if there is no unconformability between the upper Llandeilo and the Caradoc formations, the downthrow of the Caradoc beds, situated on the east side of the Stretton fault, must extend through the whole of this enormous thickness of the Cambrian and Llandeilo formations, plus that of the Caradoc beds, and a thickness of strata to the same extent must have been upheaved and subsequently denuded prior to the deposit of the upper Llandovery, as rocks of that age are lying unconformably on these Caradoc beds, and on the upturned edges of the strata of the Longmynd and Shelve hills.

But there is much less similarity between the fauna of the Llandeilo and of the Caradoc than there is between that of the latter and of the upper Llandovery formation, which, as it leads to the inference that a much greater interval of time has elapsed between the former than the latter periods, renders it more probable that the first upheaval and denudation of the Longmynd took place prior to the deposit of the Caradoc, and that the latter was deposited on the eroded surfaces of the former. That by a second upheaval, during which the Stretton fault was first formed, the Caradoc rocks have been entirely denuded from the Longmynd and Shelve hills, but the upper beds only

have been removed on the east or downthrow of the fault. It is upon these eroded surfaces that the upper Llandovery formation has been deposited. By this theory the throw of the Stretton fault will be reduced to the comparatively moderate but still very large amount of the thickness of the Caradoc formation only.

DESCRIPTION OF A FAULT IN A GRANITE QUARRY AT ABERDEEN.

BY GEORGE H. MORTON, F.G.S.

IN September last, in company with Mr. T. J. Moore, I had an opportunity of examining a granite quarry at Aberdeen. It is the largest and the nearest one to the city, being only two miles from it, in a northwesterly direction. The granite is mostly of a grey colour, though frequently of a reddish tinge, in consequence of the feldspar assuming that tint. It is traversed by joints in several directions, and it is unnecessary to describe it further, with the exception of stating that a band of a stratified character, about a foot in thickness, was noticed to be cut off by the fault which it is the object of this communication to refer to.

The fault is conspicuous in the rocky wall at one side of the quarry, and varies in width from six to twelve inches. It is filled with granite on one side and mica schist on the other, the foliation of the latter being coincident with the hade of the fault. Having seen hundreds of faults in regularly stratified rocks, containing sandstone and clay, occupying similar positions to the granite and mica schist in the fault described, and not having seen a parallel example before in any granitic district, I concluded that it was worth recording.

The contents of the fracture cannot be considered to be

of an eruptive character, for it presents the appearance of an ordinary dislocation, while the occurrence of foliated schist is altogether against such a conclusion. From the appearance of the fault I concluded that its contents had been metamorphosed by hydrothermal action, which altered the original sandstone and clay into granite and mica schist, the lithological character of the latter having been determined by lamination and chemical composition.

DECEMBER 10TH, 1867.

THE PRESIDENT, R. A. ESKRIGGE, F.G.S., in the Chair.

W. HOPE JONES was elected an Ordinary Member.

The following communications were read :—

OBSERVATIONS ON THE SHORE BETWEEN THE MERSEY AND DEE.

BY CHARLES POTTER.

The publication of this paper is unavoidably postponed.

GEOLOGICAL OBSERVATIONS ON THE COUNTRY ROUND MAENTWROG, NORTH WALES.

BY R. A. ESKRIGGE, F.G.S.

IN a former communication which I had the honour to read before this Society, I pointed out that the geological structure of that portion of North Wales lying between Snowdon and Cader Idris, though apparently very complex, is in reality most simple. The key to it is found in the anticlinal arch of lower Cambrian rocks which extends from

near Ffestiniog on the north, to Harlech on the south, the various members of the upper Cambrian and lower Silurian formations succeeding in their natural order on both sides of the arch. On the northwestern flank of this anticlinal the natural order is preserved almost unbroken until we have travelled some miles north of the sugarloaf mountain called Cynicht; but on the eastern or Dolgelly side the strata are much shattered, and it has required both long labour and a high degree of geological skill on the part of the officers of the Survey to unravel the true succession of beds on a small scale, though viewed broadly the sequence is unmistakeable.

I do not know any tract of country where the physical succession of great mountain masses is more clearly visible on a mere surface inspection than that lying between Trawsfynydd and Snowdon. Take first the Harlech grits, the lowest rocks of the district. The bold ridge of hills which runs up from the coast terminates two and a half miles from Maentwrog, in a truncated elliptical boss, and the thick beds of coarse grit and conglomerates of which it is composed are seen, like giant steps, running along the hill sides, succeeding each other with as much regularity as the coats of an onion.

To these succeed without any known unconformity the various members of the upper Cambrian and lower Silurian formations, consisting of shales and slates of various colours and degrees of hardness, but all much softer than the underlying grits. This comparative softness will account for the immense denudation to which the district has evidently been subjected. These slates and shales have everywhere a northwesterly dip, which is visible to the geological eye even when viewed from a distance, the occasional harder beds standing out in miniature terraces and ridges.

Passing now some miles to the northwest over the Lingula beds, the Tremadoc, and lower Llandeilo, let us take our stand at the southern end of the valley of Cwm Croesor, or, better still for our present purpose, a few miles further south near Portmadoc. The valley of Croesor is evidently one of denudation, and does not appear to have any fault running down it; it separates the two fine hills, Cynicht lying to the west, and Moelwyn to the east. Upon the flanks of these two mountains the lines of stratification are most beautifully seen, and upon Cynicht can be traced almost from summit to base. Now, viewing the two mountains together, we see at once that a prolongation of the lines of stratification on Cynicht would carry the beds of which it is composed right over Moelwyn, and that if thus prolonged they would raise that mountain to an elevation of between 7,000 and 8,000 feet; and scarcely any one, whether a practised geologist or a mere common-sense observer, could doubt, if he reflected for a moment, that the strata were really once thus continuous. This is one of the most interesting proofs I know of the extent of denudation which this country has undergone, and its extreme simplicity makes it the more striking.

But if the beds of Cynicht were continuous over Moelwyn, so, by the same laws of reasoning, these in their turn must have extended over the Tremadoc and Lingula beds and right on over the Harlech grits. Were all these lost beds restored in their true position, and the sea level remained as at present, we should have a range of hills rising to 20,000 or 25,000 feet, as has been shown in detail by Professor Ramsay. But I am now speaking of the mere surface indications of these geological changes.

The publication of the last Memoir of the Survey upon North Wales has added much to our knowledge of the country, and from a succession of rambles taken with this

book in hand, I can bear testimony to the extreme accuracy with which even the minute geological features are recorded. Since the Survey was completed, however, the labours of many zealous workers have necessitated, upon palæontological grounds, a more minute subdivision of the strata than was then practicable. Many new fossils have been discovered, and by means of these some progress has been made in separating the thick mass of strata lying between the Cambrian and Llandeilo into well-defined groups, though their physical boundaries upon the map remain to be worked out. As you well know, upon the Survey maps the lower Silurian and upper Cambrian beds are all coloured one tint, and only roughly distinguished by numerals in their order of succession—b^1 Ling. beds; b^2 Landeilo; b^3 Caradoc, &c.

The first step in the disturbance of this arrangement arose from the discovery of the rich and peculiar fauna of the beds lying around the village of Tremadoc. This series is of considerable thickness, and as it could not be united with either the underlying Lingula beds or the overlying Llandeilo, it had to be erected into a distinct subdivision; but it is not marked at all on the maps. At first it was supposed to be quite local, extending only a few miles northeast of Portmadoc; but very recently it has been satisfactorily determined by Mr. Belt on the other side of the anticlinal, establishing another link in the chain of evidence of the former continuous connection of the higher beds over the now uplifted arch. The Tremadoc beds contain nearly forty species of fossils belonging to twenty genera, and scarcely any of the species pass upwards. In the discovery of the Tremadoc fossils the place of honour belongs to Mr. Homfray, who has worked out the minute geological features with a perseverance which amply deserves the success it has achieved.

The next step was the interpolation of the Arenig group of Sedgwick between the Tremadoc and Llandeilo. Its fossils have been chiefly worked out by Mr. Salter, and the succession is now established, not only in the typical district near Mount Arenig, but also above Garth-hill, near Tremadoc, and in many other localities both in North and South Wales.

Then came the remarkable series of discoveries of Messrs. Salter and Hicks in South Wales, proving the fossiliferous character of the rocks deep down into the old Cambrian, the latest trophy being from the pure red beds of that formation, which in all probability are the true equivalents of the Harlech grits of North Wales. This has necessitated the separation of these fossil-bearing beds into a new group, to which the name of Menevian is given.

Still more recently again, we have a proposal from Mr. Belt (who with most praiseworthy energy has devoted three years to the detailed examination of the mass of strata between the Menevian and Tremadoc, on the east of the anticlinal near Dolgelly), to divide the series now known as Lingula beds into no less than three divisions, for which he proposes the names of Maentwrog, Ffestiniog, and Dolgelly groups. In the November and December numbers of the "Geological Magazine" Mr. Belt clearly summarises the evidence in favour of this course, both upon palæontological and stratigraphical grounds. Having enjoyed a day's ramble over the district in question with Mr. Belt, I feel bound to record my admiration of the most conscientious accuracy with which every detail of the country has been mapped and studied by him; and whether his proposed subdivisions meet with general acceptance from geologists or not, he has certainly added greatly to our knowledge of the beds in question, and given to the scientific world many hitherto undiscovered forms of animal life. In fact, he and

his associate Mr. Barlow have been doing for the Lingula beds what Mr. Homfray did for the Tremadoc, and Mr. Hicks for the Menevian.

I have hastily run over the history of these successive discoveries, in order to remind you of the present state of our knowledge regarding these old rocks. Instead of the division of the lower Silurian, as first proposed by its founder, simply into Bala, Llandeilo, and Lingula beds, we have now the lower Llandovery, Caradoc or Bala (most likely to be divided once, if not twice), the Llandeilo, Arenig, Tremadoc, Dolgelly, Ffestinoig, Maentwrog, Menevian, and the Harlech grits. All contain distinct though perhaps allied faunas. No doubt this process of subdivision may easily be carried too far, but it is very useful for working out details of a country and correlating the strata in one district with those in another; and the distribution of fossils in all the groups supports the conclusion that various forms of animal life affect particular and limited zones, and after once dying out, seldom or never reappear.

Coming now to the immediate subject of this notice—the district a few miles round Maentwrog—I find much that I had intended to bring forward anticipated by Mr. Belt in the paper alluded to just now; and some of the features of the country are described by him much better than I could have hoped to do. Except some 400 to 500 feet of Menevian beds lying immediately upon the Harlech grits, the whole of the strata between the lower Cambrian and the village of Maentwrog are included in Mr. Belt's Maentwrog group; and allowing an average dip of 30°, I calculate their thickness up to the Harlech road at the foot of the Waterfall Valley at some 2,600 feet, which closely coincides with the measurements given by Mr. Belt for the same beds on the other side of the anticlinal. The best sections are along the brook running down from

Tafarn-helig, and on the course of the river which flows down the Waterfall Valley. The beds are traversed by numerous bands of greenstone, which seem at first sight to be truly contemporaneous. Mr. Ramsay asserts that none of them are strictly so; and though on my first two visits to the locality I felt strongly inclined to hold a contrary opinion, further investigation leads me to believe Mr. Ramsay is correct, and that though lying in nearly parallel planes to the stratified rocks, the igneous beds will always, or nearly always, be found to cut more or less across them when carefully followed, and are thus proved to be intrusive.

My chief object in my last visit was to examine the Menevian beds more carefully and trace their extension. Up to this summer they were known on the west of the anticlinal only at the northerly extremity near Tafarn-helig, as described in my paper read before you in 1866. It was not known whether they were exposed at all further south, or whether they were overlapped by the superincumbent strata. The Waterfall Valley had seemed to me the most likely locality for their occurrence if exposed, and upon mentioning to Mr. Homfray, of Portmadoc, my intention of searching for them there, I learned that he had himself conceived the same idea, so we determined to make the search together.

The exact locality we fixed upon to commence our researches was just beyond the bridge which crosses the stream, some half-mile above the fall, the strong lithological resemblance which the rocks here bore to those of Porth-y-Rhaw, in North Wales, having suggested this as the best hunting ground.

Almost the first blow of the hammer rewarded the writer with a fine *Erinnys*, one of the characteristic trilobites of the St. David's beds; and thus encouraged we worked away

until we had found most of the now well-known Menevian fossils, and established a close conformity of the beds here both with those on the other side of the anticlinal and also with those of St. David's. *Paradoxides Davidis* occurs here plentifully; but singularly enough there are at least ten heads for one body or tail.

Subsequently we traced the beds at several points along the line from this valley to Tafarn-helig. In many places they form quite an escarpment, apparently due to a fault. The lowest fossil we found was *Paradoxides Hicksii*, occupying precisely the same relative position as in South Wales, a laborious search for two days in lower beds being fruitless. At St. David's some 300 or 400 feet of strata lower than this are now found fossiliferous; and I have little doubt that further research in this locality will establish the same for North Wales. On my last visit, undertaken with this special object, the height of the river prevented my doing anything. On some future occasion I hope to clear up the point, and also, with the experienced aid of my friend Mr. Homfray, to construct a detailed section from the Cambrian to the higher Lingula beds.

The following is a list of the fossils found:—

Paradoxides Davidis, *Paradoxides Hicksii*, *Anopolenus Henrici* (which I believe is a species of *Paradoxides*), *Conocoryphe*, three or four species, including probably one or two new ones; *Erinnys*, *Microdiscus*, *Agnostus* 2 *sp.*, *Obolella*, *Lingulella*, *Theca*, *Protospongia*, and some doubtful forms, amongst which is, I believe, a new species of *Orthoceras* now in Mr. Salter's hands.

There is still much work to be done in this field before the survey is complete, and doubtless there are many hitherto undiscovered remains of animal life entombed in the rocks to reward the toil of any who deem it a labour of love thus to investigate nature's arcana, in the midst of a district of much scenic beauty.

JANUARY 14TH, 1868.

THE PRESIDENT, R. A. ESKRIGGE, F.G.S., in the Chair.

HENRY J. GIBBON was elected an Ordinary Member.

The following communications were read:—

ON SOME FOSSIL MAMMALIAN REMAINS FROM SOUTH AMERICA, IN THE FREE PUBLIC MUSEUM OF LIVERPOOL.

BY THOMAS J. MOORE, CORR. MEMB. ZOOL. SOC., LOND., CURATOR OF THE MUSEUM.

IN addition to the princely gift of his magnificent Museum of Antiquities, lately made to the town of Liverpool by Mr. Mayer, he has since added a large case of fossil remains, sent to him some years back from South America by a friend.

These remains, on examination, were found to consist of the following specimens:—

A very considerable series of dermal scutes of a Glyptodon, amounting to several hundred pieces, the great majority being separate scutes, though some few were still united in masses, but not larger than could be covered by the outspread hand. The greater part have been successfully matched and pieced together, giving a surface about five feet by four feet measured over the curve.

The scutes, though presenting an appearance of all belonging to one individual of the species, still show considerable variations of form and pattern. The majority are more or less regular hexagons, but some are four-sided (a few nearly square), while others are five, seven, or occasionally even eight-sided. Their general diameter is one and a half inches, and only in rare instances do they exceed two inches in any superficial dimension. They vary in thickness from three quarters of an inch to an inch and a half.

The outer surface of each has a well-marked pattern, which is, of course, wanting on the inner surface. This pattern consists of a central, more or less circular, disc, surrounded usually by six, but sometimes by seven or even eight, outer discs, of nearly similar size and somewhat angular character, the face of all being of a uniform level (though more or less pitted), and all being separated from each other by a well-defined groove. In some few, however (probably approaching the margin of the shield), the central disc covers nearly the whole of the scute, and measures nearly an inch and a half in diameter; the ordinary diameter being about three quarters of an inch.

There are a few bosses, evidently belonging to the marginal border, which are of a somewhat swelled, irregular form, and measuring two to three inches across and an inch and a half thick.

It would seem that the form and pattern of the scutes vary according to their position in the carapace; the thinner and more uniformly-marked ones belonging to the more central parts of the shield, and the thicker and less regular belonging to the outer portion.

This remark would seem to hold good not only in the above example, but also in the cast in this Museum of the entire carapace of a *Glyptodon (Schistopleurum) typus*, received from Mr. Ward, of the University of Rochester, in the State of New York, the original of which is in the Museum of Dijon, and which would appear, from the size and pattern of the scutes, to be of the same species and nearly the same size as the animal indicated by these remains from Mr. Mayer. The original of this cast, too, appears to have been a work of labour in piecing the several parts together, even if not in some parts an actual restoration. This broken up, fragmentary condition, would appear to be the state in which these remains are found;

such, I am told by Mr. Waterhouse Hawkins, was the condition of a Glyptodon carapace which he had been engaged in putting together at the Museum of the Royal College of Surgeons, London; such, also, is the condition in which Mr. B. M. Wright, of Great Russell-street, London, has received such scutes as have come into his possession. Those received from Mr. Mayer were thickly covered with dried mud.

It is curious to note that when the scutes are joined together their individuality is in many places so little indicated that the pattern is not self-apparent, but has to be traced out in order to see that it is in the main composed of a central disc surrounded by six or eight others.

The second item in this collection is an example of the left femur of an elephant or mastodon. Though broken in two across the middle of the shaft, and the upper portion still further broken, the component parts have nearly all been preserved by means of leather thongs, with which they have been securely retained in their respective positions.

I have compared this femur with the corresponding bone of an immature Indian elephant, which stood, when living, eight or nine feet high, but in which the epiphyses are as yet unossified. In the fossil femur ossification has been fully completed; and though but little longer than the recent one, the fossil femur is very much stronger and stouter.

The dimensions are as follows:—

	Indian Elephant. INCHES.		Mastodon. INCHES.
Total length	36	..	42
Greatest breadth at upper end	12	..	15
Greatest breadth at lower end	8	..	10½
Smallest circumference (in middle of shaft)..........	11½	..	ABOUT 16

The third and last item in the series consists of the coalesced sacral vertebræ of a Megatherium, measuring 18 inches in length, but so much broken as to consist of little more than the centrum and neural arch of each; the latter being in some imperfect on one side.

Unfortunately I have no information as to the district whence these interesting and valuable remains were obtained.

ON THE GEOLOGY OF THE COUNTRY AROUND SHELVE, IN SHROPSHIRE.

By G. H. Morton, F.G.S.

The publication of this paper is unavoidably postponed.

FEBRUARY 11th, 1868.

The Vice-President, Dr. RICKETTS, F.G.S., in the Chair.

William G. Drysdale and Alfred Morgan were elected Ordinary Members.

The following communications were read:

REMARKS ON THE UPPER SILURIAN FORMATION.

By Charles Ricketts, M.D., F.G.S.

There is a great similarity in the nature of the materials which, in the Dudley and Wenlock districts, enter into the composition of the upper Silurian formation; the whole series of beds, from the horizon of the Woolhope Limestone

to near the upper beds of the Ludlow rocks, consisting almost essentially of the same muddy deposit, the only exceptions which I have observed being the different bands of limestone, the slabs of which are separated from each other by partings of the same mud, and it likewise enters into the composition of the limestones themselves. Combined with this similarity in the nature of the deposit, there is also perfect conformability throughout the whole series. It appears, therefore, that the whole of this great deposit must be attributed to the long continuance of one cause; but with, at the times represented by the different bands of limestone, a partial interruption to the deposit of mud, when in the clear waters of this Silurian sea, animal life abounded in a manner strongly contrasting with its comparative rarity when the waters were surcharged with mud.

More towards the west the Wenlock rocks still consist of mudstone shales, but the particles are coarser than in the Shropshire and Staffordshire districts, and the limestone is absent; whilst at the extreme west the base of the deposit, the Tarannon shale is, through the greater portion of its extent, surmounted by a succession of sandy beds constituting the Denbighshire grits.

At the flagstone quarry in the Wenlock formation, four miles north of Llangollen, the strata, which are exposed for a thickness of many scores of yards, consist throughout of a series of ripple-marked beds, with other indications of a deposit in shallow water. There are likewise in these unaltered strata and in the slaty rocks beneath, an abundance of nodules of various sizes, having the same mineral composition as the beds themselves; they are not concretionary, but appear like boulders which have settled down into the soft mud at the time the formation was in progress, having pressed the lines of stratification beneath them closer together.

The only cause to which I can attribute these phenomena is the continuous action of some great river which, charged with the *débris* of the land, has during the whole period brought down this muddy sediment, the force of the stream and of the tide carrying it forward into what was then a Silurian sea, and depositing it in deep water.

I imagine that the fine mud constituting the Tarannon shale has been carried forward and deposited at a distance from the land; but as materials accumulated near the mouth of the river, and the depth of water became diminished, the force of the current would carry forward the heavier particles, viz., the sand and silt which are represented by the Denbighshire grits, whilst the finer mud, having been carried beyond the power of the stream, was deposited far out at sea.

During the periods which are represented by the limestones there might possibly have been changes in the direction of the channel, by which sufficient distance was obtained to allow the insoluble matter to be deposited, when the water, cleared of its muddy impurities, would discharge itself of the lime it had retained in solution as a soluble bicarbonate. As all the bands of limestone are situated on the eastern side of the formation, whilst the Welsh districts are represented by shales and grits only, there probably have been no material changes in the general direction of the current, which continued nearly due north and south, the land which was suffering denudation being situated towards the north. This same distance has more likely occurred in consequence of depression of the land near the delta or estuary, in the same manner as it is found to be now taking place at the mouth of very many great rivers ("Lyell's Principles of Geology," chap. xvii and xviii), due, as I imagine, to the weight of the materials which they bring down causing pressure on the crust of the earth,

and, as a consequence, depression of the land. There is abundant evidence of subsidence not only in the successive ripple-marked beds of the flagstone quarry, but also in the much greater accumulation which has occurred subsequently. To a succession of such subsidences I would attribute the deficiency of the deposit of mud in the Shropshire and Staffordshire districts, during those long periods of time which are represented by the different beds of limestone ranging from the Woolhope to the Aymestry bands. If the Llangollen district at one period during the Wenlock age formed a portion of the delta of a river, a rational explanation may be afforded of the presence of the nodules which are so remarkably embedded in the rocks, by considering that the action of the river and tidal currents undermining the banks washed away masses, which took a rounded form in consequence of the plasticity of the mud, and eventually were deposited on a lower terrace, or in the bed of the stream.

This theory, attributing the origin of these formations to the *débris* brought down by river action, requires confirmation by an examination of the North Lancashire, Westmoreland, and other districts.

THE PROBABLE SOURCE OF HOLYWELL SPRING.

By Robert Bostock.

On beholding the Spring of Holywell, the thought naturally suggests itself to the mind as to where such a quantity of water could come from. However, such were my own thoughts concerning it; but for years it was a problem which I in vain attempted to solve. I could not take a

single step in the way of accounting for it. At length it occurred to me that in passing along the Holyhead line I had never noticed streams of any importance crossing it, the whole distance from Queen's Ferry to Mostyn. As the railway is bounded throughout by a range of hills from five to nine hundred feet high, the drainage of which must be something considerable, it seemed but natural to expect that this should make its appearance somewhere. The question was then—Did the rainfall of the district find its way to the sea through the Vale of Clwyd, or could the Holywell Spring possibly be the outlet for such? To ascertain this it was necessary that the country to the rear or southward from Holywell should be examined. This I have been in the habit of doing for years, crossing and re-crossing it in every direction, inquiring the depth of mines which came in my way, and sounding others which were abandoned, and the conclusion arrived at from the whole is, that Holywell Spring is due mainly to the rainfall, with possibly a contribution from the River Alyn, which may find its way there by means of a cross course or large fissure in the earth, which traverses the country from Holywell in a southerly direction for about fifteen miles, and which in its course crosses the Alyn several times, and for half a mile forms the bed of a stream, at a point too where the river is nearly 700 feet above the sea level; the same fault throughout its course being intersected by numerous lead veins. I will now describe the country in order to establish these points.

From Greenfield up the valley to Holywell there is a slight ascent, the point where the Spring issues being, I believe, 108 feet above low water mark; from thence a sudden rise takes place, so that in High-street the elevation is 362 feet. Proceeding southward a short distance the summit of Pen-y-Bryn is gained, which is upwards of 800 feet.

On ascending a mountain we expect to have to descend the other side, but in this case it is not so. When the height is attained it is seen to be a steppe or plain stretching away for miles, the surface of which is undulating, consisting of beds of gravel, limestone *débris*, sand, and clay, and covered generally with a short green sward; a few cottages clustered together here and there, inhabited by miners; not many inclosures; no watercourses of any kind, nor any occasion for them apparently, for there is scarcely any water to be seen: when rain falls there is just sufficient grass to retain it until it sinks into the ground and disappears, so that very little runs off. The underlying rock is limestone, and wherever bared, as in quarries or mines, is seen to be bedded, split up in every direction, and honeycombed by water passing through and dissolving it. Every quarter of a mile or so lead veins traverse the district from east to west. These penetrate to an unknown depth. Crossing these nearly at right angles are large faults or cross courses, which must certainly descend into the interior of the earth. The cross course which I allude to in particular, and which I think serves as a conduit to convey water to Holywell, is known to miners as the Galopall cross course; its direction is nearly north and south. There appears to have been no upheaval consequent on it; but it completely severs the country for nearly twenty miles. This appears to be connected with another one known to geologists as the Yale and Bala fault, which commencing near the Rosset station passes through Minera mining district, Corwen, Bala Lake, by Cader Idris to the sea near Towen, thus cutting North Wales in two, and placing strata thousands of feet out of their original position. The Galopall fault is doubtless a fracture consequent on this, and the lead veins which intersect it are minor dislocations. The junction of these two large faults takes place in a wild mountainous district above

Minera. The River Alyn too (the one seen at Mold and Gresford) has its rise in the same locality, at an elevation of about 1800 feet; from thence both river and cross course trend towards Holywell, running parallel for miles in a deep, wide valley. They begin to intersect near Cilcen, where may be seen in the bed of the river several large cavities, or what are called swallow-holes. That any water passes these seems to be owing entirely to the swiftness of the current. The river at this part is called Hesp Alyn, or Dry Alyn. In summer, when the water is low, boys amuse themselves by damming up the stream below these holes and turning all the water down them. Where this goes to is not so clear; but the mine proprietors in the neighbourhood of Mold appear to think that it finds its way into their workings, and they have had it in contemplation to construct an artificial channel for the Alyn. A few thousands spent in this way they think may save them many thousands in the shape of coal for pumping this water out of the mines. If such scheme should ever be carried out, I fear the only certainty about it would be the expenditure. An undertaking of that kind must be hazardous under any circumstances, but is doubly so wherever limestone is concerned. Immense wealth has no doubt been obtained from lead mining in this district, but it is a question whether more wealth has not been expended in order to obtain this. At present mining operations are nearly at a stand, not on account of the ore failing, but owing to the expense in freeing the mines of water; the only exceptions are a few instances where the fault in which the ore is deposited happens to be so narrow that they can pump the water out faster than the fissure will admit it. One of the mines I visited, although only 300 feet deep, required two engines, one 100 and the other 80 horse power, to keep the water under, and some of the men employed there have to work

nearly knee deep in a stream of water which runs past them from the cross course to the pumps. This same mine has been worked twenty-five years, and during that time five or six men have been constantly engaged washing clay and rubbish taken out of the mine for the sake of the ore it contains. Now, it is evident that previous to the deposition of this clay a cavity must have been hollowed out to receive it; but what sized cavity must it be to require so many men so many years, and not emptied yet?

Near this lead vein and within a few yards of the cross course was formerly an intermittent spring known as Ffynnon Lleinw (the ebbing and flowing spring), but since mining has been carried on there it has ceased, the incessant pumping having apparently lowered the mean level of the water, but when in operation it appears to have acted as an overflow pipe.

There is nothing unreasonable in the supposition that the district under consideration may be cavernous—most limestone is so; for instance, the Kirkdale Cave, Yorkshire; Mammoth Cave, Kentucky; the Adelsberg Cave, Austria. These are of great extent, and into the last of which the River Poick flows and is not seen again; however, not as a river, there are several large lakes a few miles off without any visible source—the river doubtless under another form. In Spain, the River Guadiana flows underground for thirty miles. From where the Alyn is seen to flow into the fault to the Spring at Holywell is a little over six miles. To see the water sink into this fault, walk along it nearly in a straight line to Holywell, and see water issue out of a fault there, one can scarcely avoid the inference that there is some connection between the two. The mean level of the water in the cross courses and mines in the district to the rear of Holywell appears to be from two to three hundred feet above the sea, for there are but few instances where mines

have been carried below this. A further proof that the Holywell Spring is dependent on the rainfall is the fact that after rain the water is always muddy; and towards the end of summer, when no rain has fallen for some time, it is noticed not to flow quite so strong. Much difference of opinion exists as to the quantity of water thrown up by the Spring. I measured the conduit or race which conveys the water away, and found the space occupied by water to be about six and a half square feet. This would allow 4,400 gallons per minute to pass; this, at ten pounds per gallon, would be nearly twenty tons per minute, and is equal to about twenty-five horse power on a given point. As the water has a fall of 100 feet on its way to the Dee, this has been taken advantage of, and there are several waterwheels upon it for one purpose or another; but since the steam-engine came into such general use they are not in so much request, and several of them are now falling into decay.

As regards the valley in which Holywell is situated: this appears to have been the work of the Spring, whose point of discharge may formerly have been nearer, or even where the Dee now flows, and which has cut its way back and back; and if the heights above Holywell had not been capped with chert or flint, doubtless long ere this it would have opened up a course for itself miles back into the country along the cross course before alluded to, and have appeared as ordinary valleys, instead of ending, as it now does, abruptly. The clay, &c., seen in the valley is what was deposited during the last submergence of the land. The clay cliffs along the shore from Mostyn to Hawarden are due to the same cause.

As to the length of time the Spring may have flown, of course it can never be known; but if it should arise out of the Galopall cross course, it is clear it could not have been before this fissure was formed. When that happened we

know not; but it must have been previous to the formation of the New Red Sandstone we see around us, for this wraps round and is not affected by the faults in the limestone. Of the comparative age of the New Red Sandstone of course you, as geologists, are well aware.

Should this view of the origin of the Spring be objected to, it would be requisite to show what otherwise becomes of the water of the Alyn seen to enter the swallow-holes, and of the rain which falls on so many square miles of surface.

MARCH 10TH, 1868.

THE PRESIDENT, R. A. ESKRIGGE, F.G.S., in the Chair.

The following communications were read:

ON THE GEOLOGY OF THE DISTRICT OF CREUDDYN.

By HUGH F. HALL, F.G.S.

This was the concluding part of the author's paper, commenced November the 12th, 1867, and the whole of the communication will be found under that date.

ON THE RELATION OF CHEMISTRY TO GEOLOGY.

By A. NORMAN TATE, F.C.S.

THE object of this paper was to point out that geologists do not pay sufficient attention to the chemical phenomena

which accompany geological changes, and that consequently they fail to avail themselves of much valuable information calculated to materially assist geological inquiries. After a brief survey of the objects and field of operation of the two sciences, the author urged the necessity for a more attentive study of chemistry by geologists for the following reasons:—

First.—That chemistry, embracing such an extensive, almost boundless field of operation, must of necessity have assisted materially in the changes of which geology takes cognizance; and that, without the study of all the elements of such changes, they cannot be fully understood, and, therefore, any opinion formed respecting them must necessarily be incomplete, if not inaccurate; and there is danger in promulgating such opinions.

Second.—That the information given by chemistry is valuable not only for its *quantity*, but for its *quality*. Chemistry is most inquisitorially scrutinising in its investigation: it searches out the very innermost properties of the substances it examines, shows their relation one to another, and affords information complete and exhaustive in its character. The quality of the information given by chemistry is also valuable from the fact that chemical changes are, as a rule, very decided in their character, affording results that vividly impress them upon the student. Chemical changes are generally complete transformations.

Third.—Apart from the foregoing considerations, the study of chemistry may be serviceable to geologists as a matter of discipline for the mind. Geologists, dealing as they do with immeasurable periods of time, and with operations taking place on a gigantic and marvellous scale, are too apt to indulge in wide generalities, without descending to minute facts, which often upset theories based upon larger

considerations only. The study of chemistry is eminently suited to counteract this.

Fourth.—There are many other points connected with chemistry which might serve the geologist as models—as, for instance, nomenclature. How much easier is it to study chemistry because the nomenclature is based upon a philosophic and intelligible plan than it is even to remember the names of rocks and minerals used by geologists and mineralogists!

As to the manner in which chemistry should be made useful in geological inquiries, the author considered it under two heads, viz.:—

First.—By careful and exhaustive analyses of the rocks and minerals as they exist at the present time, and the attentive study of the properties of their constituents under all circumstances to which they are likely to have been exposed in order to be built up where we find them. Possessed of a knowledge of the composition of a rock, and the relation of its constituents to each other, and to all other bodies occurring in nature, we can form a tolerably correct idea as to how and from what it has been formed. We may possibly even obtain from its chemical character some clue respecting its age.

Second.—The attentive study of the chemical conditions accompanying the various processes of rock formation and other geological phenomena now going on around us. The geologist when studying chemistry must not be satisfied with mere laboratory practice. He must go out into the world and examine there all the conditions under which changes are taking place. He will then note many minute and apparently trivial circumstances which most materially affect the processes, and which would in no way enter into his calculations if he confined his labours to his laboratory.

Surely a science so severely scrutinising in its investigation, so active, so powerfully transformational, so extensive in its operations, so capable of explaining natural phenomena, and withal so clear and accurate in its teachings, deserves more attention from geologists than they are accustomed to give to it.

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OF THE

PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

SESSION THE TENTH.

1868-69.

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1869.

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ABSTRACT OF THE PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL SOCIETY.

SESSION TENTH.

OCTOBER 13TH, 1868.

ANNIVERSARY ADDRESS BY THE RETIRING PRESIDENT, R. A. ESKRIGGE, F.G.S.

THE swift passage of the months has brought us to the commencement of another winter session, and before resigning the chair in which your indulgence has placed me for the past two years, it becomes my duty to present to you a few remarks, which will be of a somewhat discursive nature. Last year I ventured to review some of the physical changes to which the area of the British Isles had been subjected in Palæozoic ages; and it was my intention to have pursued on this occasion a similar line of treatment, with respect, at least, to the Mesozoic period. Various circumstances, however, have conspired to prevent the fulfilment of this intention, and whilst hoping at some future time to carry out the idea, I must content myself now with a brief review of some of the more recent contributions to the science of geology.

And first, as of most immediate interest to ourselves, let me say a few words upon the position of our own Society. We are now entering upon our tenth session, and the number of members, which at first was six, has increased to fifty-six. Still, within the last four years there has been no advance, the withdrawals, from various causes, having slightly exceeded the number of new members. On the whole, however, I am inclined to regard the numerical position of the Society as satisfactory, considering the small attraction to the study of our science presented by the more prominent features of local geology. But when we turn from the number of nominal members to the transactions, and see the small proportion who take active part therein, there is cause for regret and disappointment. This point has been frequently referred to, both by myself and previous occupants of this chair; but I feel unwilling to resign my office without again urging all the members to bring forward notices, however short, of any observed facts, even though they may hesitate to commit themselves to more lengthy communications. When once a member has contributed to the proceedings of the Society, he will feel a more personal interest in its activity and wellbeing.

The abstract of last session contains some papers of more than local interest. The first in order is by Mr. H. F. Hall, F.G.S., and gives copious details of drift sections in the district of Creuddyn, between Colwyn and Llandudno, the chief feature of interest being his observation of the extensive denudation to which the lowest bed of "boulder clay" has been subjected, before the higher beds were deposited. The term "boulder clay" is restricted by Mr. Hall to this lowest bed; the red clay which extends so widely over the district being referable, in his opinion, to a much later epoch, when the intense cold of the true

glacial period had given place to a more temperate climate.

This paper gave rise to considerable discussion, several of the members warmly contesting the desirableness of restricting the term "boulder clay" to one bed, seeing that it has usually received a much wider application. The theoretical views, also, advanced by the author with regard to the conditions of deposition of the various beds, did not pass without criticism.

Dr. Ricketts, F.G.S., contributes two thoughtful papers —one, upon "The Upper Silurian Formation," which he regards as mainly the result of deposition by a large river, the estuary of which lay in the neighbourhood of Llangollen. The other was entitled "The Succession of Strata in the neighbourhood of Church Stretton." The theories of the writer on both these subjects invited and received pretty lengthened criticism.

The most lively interest of the session, however, arose from a paper by Mr. Potter, entitled "Observations on the Shore between the Dee and the Mersey." We much regret to find this valuable communication omitted from our published proceedings, as it evinced unwearied diligence in the collection of facts, and considerable ingenuity in support of the conclusion towards which it was mainly directed, viz., that the so-called "forest bed," at Dove Point, was formed from drifted materials, and that the trees, whose stumps and roots are now to be seen there, did not grow on the spot. As we are promised a further communication by Mr. Potter, on the same and similar beds elsewhere, during the present session, which we hope will be embodied in our next abstract, I will not anticipate its interest by entering now upon the discussion of this very important question.

Our indefatigable secretary, Mr. G. H. Morton, F.G.S.,

read two papers—one, "On a Fault in a Granite Quarry at Aberdeen;" the other, a continuation of his valuable series of communications on the geology of Shelve, in which a copious list of the fossils gathered by the author is given, and likewise some interesting details of the directions of the ore veins, and the general mining features of the country. The publication of the latter paper is delayed.

Mr. Bostock contributed a paper upon "The Probable Source of Holywell Spring," which I regard as one of the most valuable read before the Society. It evinces a minute knowledge of the geological structure of the country, and the power of sound, careful reasoning in the closet upon observations made in the field.

Mr. Moore, the talented curator of our local Museum, described some fossil Mammalian remains from South America, recently added to the Museum. The fossils are of considerable interest; but, unfortunately, much of their scientific value is lost, owing to the fact that the exact locality in which they were found is unknown.

Mr. Norman Tate read an instructive paper on the relation between chemistry and geology.

In thus summarising the work of last session, we miss with regret the names of some of our members, who in previous years bore an active part in our proceedings; and we would express the hope that their withdrawal is only temporary.

Before passing to more general subjects, there are two other matters of local interest to which I would wish to call your attention: the one is, that most probably within two, or at most, three years, the British Association will meet in Liverpool for the first time since our Society was incorporated; and as on such occasions prominence is generally given to the peculiar features of local geology, it behoves us to be in readiness for the work which then would fairly

devolve upon us. The other has reference to the course of lectures by our late Secretary, whom I have now the pleasure to address as President, in connection with the Queen's College in this town. Having myself attended this course of lectures the first year of their initiation, I have pleasure in bearing testimony to their interest and value; and as they are now, I believe, the only regular lectures on geology in this district, I hope that all who desire to gain an insight into the principles of our most interesting and truly practical science, will avail themselves of the opportunity thus afforded.

Turning now to consider the more important contributions which have lately been made to our science, the first fact which occurs to my mind is that within the last twelve months new editions have been completed both of Sir R. Murchison's "Siluria," and Sir C. Lyell's "Principles of Geology"—the fourth edition of the former and the tenth of the latter. I know of nothing which more strikingly illustrates the rapid advance of geology than that it should have been found necessary, by both these masters of the science, within their own lifetime to publish so many editions, and not only so greatly to enlarge their volumes at each successive publication, but that in order to keep pace with all the discoveries of the day, they have been compelled almost entirely to rewrite them. I purpose now to point out some of the more important alterations and additions made in these works.

Starting, as in previous editions, with the earliest known sedimentary deposits, the first new feature presented in "Siluria" is the hearty recognition of the value and interest of the discovery, by Sir W. Logan, of Eozoon Canadense in the Laurentian rocks of Canada. Sir R. Murchison records his unhesitating belief that this much-disputed substance is truly organic, and belongs to the

class of Foraminifera. He also chronicles the discovery of the same fossil in the crystalline limestone of the older gneiss of Bavaria, Bohemia, and still more recently in Saxony and in Finland; thus adding another link to the remarkable chain of facts which establishes the identity of Palæozoic deposits over widespread areas of the earth's surface.

The evidence upon which the gneiss in the extreme northwest of Scotland was first correlated by the author with the Laurentian series is given at greater length than in the last edition, and is accompanied by the expression of a very decided opinion that these Scotch beds are the only true representatives of Laurentian rocks within the British Isles. The green limestones of Connemara, which, upon the grounds of their containing a body supposed to be identical with the Canadian Eozoon, have been classed by some geologists as Laurentian, Sir R. Murchison asserts, upon stratigraphical evidence, to be not older than lower Silurian. And whilst he seems to incline to the belief that the much controverted body found in these beds may be truly an Eozoon, he sees in this fact *per se* no proof of the age of the deposit, for he conceives it quite as possible that a being so low in the scale of organisation might have lived on from Laurentian to Silurian times, as that the Globigerina, whose remains constitute so large a proportion of the massive beds of the chalk, should be found still living in the depths of the Atlantic Ocean of to-day.

Dr. Holl's theory that the syenitic nucleus of the Malvern Hills is of Laurentian age, is also disputed, both upon lithological and stratigraphical considerations. The strike of the Malvern syenite corresponds generally with that of the beds overlying it; whereas, as you well know, the Scotch Laurentians run nearly at right angles to the strata which next overlie them, and are also separated from

them by a marked unconformability. It is worthy of note, however, that the assertion that the Malvern syenite is of purely igneous origin is modified in this new edition; and it is now conceded that it may be metamorphic. There is also a quiet abandonment of the theory formerly advanced by the author, that the most probable reason why the oldest sedimentary rocks were unfossiliferous was the greater heat of the crust of the globe which then prevailed.

The extensive additions which, during the last ten years, have been made to our knowledge of the fauna of the Cambrian and Silurian, both in North and South Wales, are noticed. But the important and very successful labours of our associate, Mr. Hicks, of St. David's, though frequently referred to in the volume, scarcely receive that full recognition which we should have expected, seeing that they have brought to light an entirely new group of fossils, from beds supposed to be destitute of all traces of organic remains; and that under the same indefatigable hammer even the Red Cambrian is now yielding up its long-buried fossil treasures. At pp. 52—3, where the St. David's group of strata is specifically referred to, it is stated that the cliffs of Whitesand Bay exhibit a continuous and united succession, from the lowest fossiliferous beds up to the Llandeilo, and that it is impossible to separate the one from the other, lithologically or stratigraphically. This, however, is by no means the case; the lithological characters of the beds containing *Paradoxides Davidis* are quite distinct from those in which the *Paradoxides Aurora* is found, the latter being in rocks, which the Survey under the direction of Sir R. Murchison himself had previously classed as Cambrian; whilst the lowest beds again present still more contrasted characters.

Instead of the various names which have been given to the different groups of fossiliferous strata lying below

the Llandeilo, viz., Arenig, Tremadoc, Lingula flags, Menevian, &c., Sir R. Murchison proposes to unite them all together under the term "Primordial Silurian." As a general and comprehensive term, this proposal certainly has strong recommendations, for the classes of animal life represented in this lower fauna undoubtedly resemble in their broad features those of Silurian age. Of course, for purposes of more minute comparison, it will be necessary still to retain the subdivisions.

In treating of the geology of the Lake District, the results of the labours of Professor Harkness and Dr. Nicholson are cordially recognised, as showing that there are no deposits in that area older than the lower Llandeilo, and many additional details are given, chiefly from the writings of the abovenamed gentlemen, tending to correlate the Silurian rocks of this region with their equivalents in other districts. The chapters on Scotch Silurian geology have also been greatly expanded, and embody the results of the energetic labours of the members of the survey, prominent amongst whom is Mr. Geikie, the local director. The volume is enriched by numerous additional sections, by which the true succession, both in the north and south of Scotland, is illustrated; but to descend into detail on these points would occupy too much of your time.

Perhaps one of the most important corrections supplied by the new edition is relative to the age of the upper Red Sandstone of Ross and Elgin. Relying upon the absence of any evidence of unconformability to the undoubted Old Red Sandstone which immediately underlies them, these beds were formerly classed as belonging to that formation, although at the time it was felt by Sir R. Murchison that the highly organised reptilian remains entombed therein presented an anomaly not easily accounted for. The recent identification by Professor Huxley of the

fossil reptiles of Elgin with the Hyperodapedon of the Warwick New Red, or Trias, is now accepted as sufficient evidence that these Scotch beds should also be assigned to the Triassic system; another proof of the interdependence of the physical geologist and the palæontologist.

Having disposed of the main features of British Silurian geology, our author proceeds to point out the vast extent of rocks of the same age in various parts of the world, and carefully notes the progress made towards a more correct determination of Silurian strata, and their fossil contents, in North and South America, in Spain, in Norway, in Bohemia, in Scandinavia, and in Russia.

To chapter xviii is appended a lengthy note "On the Origin and Mode of Occurrence of Petroleum in North America," which is entirely new. Following Dr. Sterry Hunt, it is shown that petroleum occurs at several horizons in the Palæozoic basin of North America. The lowest source is the Trenton limestone (probably of about the same age as our Caradoc), which is more or less oleiferous over a belt of country stretching from Quebec to Chicago, and southwards into Kentucky and Tennessee. The other members of the Silurian system do not *directly* yield oil, but it is found both in the upper and lower Devonian, and also, but more rarely, in some of the Carboniferous strata. Sir R. Murchison appears to accept Dr. Hunt's conclusion that the oil is indigenous to these limestones, and could not have been introduced subsequently. It is only when the beds are broken into gentle anticlinals that the oil finds its way to the surface. Too much dislocation would cause the liquid to run to waste; but the fissures produced by gentle undulations act as reservoirs to hold the oil, which is sometimes forced to the surface by the elastic gases with which it is accompanied. The origin of this remarkable substance is ascribed to a "transformation of

organic matter, whether vegetable or animal, under comparatively deep water, where oxygen was excluded, and the carbon, retaining its maximum of hydrogen, was converted into liquid or solid bitumen." To my mind, I confess this explanation is little better than an elaborate mode of expressing, whilst attempting to conceal, our complete ignorance of the subject.

The distribution of gold claims, as in former editions, a large share of our author's attention; and whilst modifying to some extent the broad generalisation formerly advanced that gold would never be found in Secondary or Tertiary deposits, except in very minute quantities, and then derived from older strata, he points out that it is only when these strata have been altered by the irruption of igneous veins that they become auriferous. After an elaborate and careful summary of the phenomena of gold distribution and mining in various parts of the world, the following conclusions are presented:—

"I.—That, looking to the world at large, the auriferous veinstones in the lower Silurian rocks contain the greatest quantity of gold.

"II.—That where certain igneous eruptions have penetrated the Secondary deposits, the latter have been rendered auriferous, for a limited distance only, beyond the junction of the erupted and stratified rock.

"III.—That the general axiom remains that all Secondary and Tertiary deposits (except the auriferous detritus from the older rocks in the latter) not so specially affected never contain gold.

"IV.—That as no unaltered purely aqueous sediment ever contains gold, the argument in favour of the igneous origin of that metal is prodigiously strengthened; or in other words, that the granites and diorites have been the chief gold producers, and that the auriferous quartz bands in the

Palæozoic rocks are also the result of heat and chemical agency."

A very strong opinion is also expressed against the probability of deep mining in quartz reefs paying, a conclusion strengthened by the results of actual experiment in nearly all parts of the world. The upper parts of the reef are generally the most auriferous; and it is because these portions have been in most cases removed by denudation, that the alluvial deposits are found to be the richest receptacles of the precious metal. A very interesting pamphlet, published by Thomas Belt, Esq., F.G.S., on mineral veins, the result both of field experience in the Australian and other gold mines, and deep chemical research, confirms the conclusions given above, and very strongly supports the igneous origin of gold and other minerals deposited in quartz veins.

The last chapter of the work has been almost entirely rewritten, though so far from abandoning the general conclusions advanced in previous editions, the author maintains that these conclusions derive additional support from recent discoveries and investigations. The most important of these is the doctrine of a general progression in the scale of organised beings, from the older to the newer deposits. The author evidently favours the theory of *distinct successive creations*, in opposition to that of progressive development, though it is at the same time admitted that such philosophical considerations do not come strictly within the province of the geologist.

From the very wide diffusion of Palæozoic strata in all latitudes, and everywhere presenting a fauna presenting the same general features, it is argued that the terrestrial conditions under which they were deposited must have been more uniform than such as now obtain; lands not very lofty, nor seas very deep, and that the temperature

was higher as well as more equable, owing to there being a thinner crust over the internal molten matter. The theories which assign glacial conditions to periods of Palæozoic ages are noticed, but altogether discarded, whether as resulting from a general law of cosmical change, such as Mr. Croll would seek to establish, or from mere local elevation of high mountain masses.

In this chapter there is also inserted an elaborate and powerfully argued defence of the old theory which assigns a much greater intensity of action to natural causes in ancient geological periods than any which have been or are in operation within the historical period. The tremendous dislocations which occur in the rocks of all ages, but especially in the older formations; the complete overthrow and reversal of large masses of strata in the Alps and other localities; the immense denudations, of which even our own island presents such striking evidence, as for instance, the Weald, the Woolhope valley of elevation, &c., &c.; the extent of metamorphic action, especially in the older deposits, are all invoked as insurmountable proofs that the causes which have produced such phenomena were not only more intense than any now at work—even granting any conceivable length of time for their operation—but, which is the main point at issue, that they were *also more paroxysmal.* Sir R. Murchison argues for the sudden elevation of vast tracts of land, and consequent extensive denudation, by waves of translation thus produced, and asks how it is, that "if our present continents and islands were gradually upraised, we do not find continuously successive lines of sea beach and shells stretching from our present shore horizon up to the highest altitudes known to have been submerged?" instead of, as we actually do find, occasional well-marked terraces of admitted sea beaches, containing in some instances, as on Tryfaen, sea shells.

Before passing from this subject I cannot help asking, What has become of the vast masses of strata supposed to have been swept away wholesale by sudden and overwhelming waves, instead of by more gradual erosive agencies? Thus violently torn away, it must have been in huge masses, as the water could not have time to wear the rock down into even moderately small fragments, much less into the highly lævigated state in which the materials of most of our strata are found. Granted that some of the conglomerates, and still more probably the breccias, were thus produced; these form but a very small proportion of the strata which must have resulted from such extensive denudations; for of course though the form may be changed, the bulk of the matter is undiminished; and if huge masses of rock have thus been swept away, they must somewhere exist; but all our researches so far have failed to find them.

The general view of a diminution of the intensity of dynamic causes from earlier to later geological ages, is (as has been already intimated) connected by our author with a supposed gradual thickening of the earth's crust, and a consequent repression of internal heat, which have permitted to our planet in these happier modern times comparative repose, and he adduces, in support of this theory, quotations from the elaborate memoir of Sir W. Thomson, "On the Secular Cooling of the Earth." The fact that the Alps have been upheaved, at least partially, in later Tertiary times, and that some of the most massive strata in which the phenomenon of reversal is witnessed belong also to this age, as well as the terrific volcanic disturbances and catastrophes witnessed within the last few years over wide geographical areas, appear to me scarcely reconcilable with this supposed decrement of internal force.

But our space will not permit longer notice of this

most interesting and masterly work. It is written throughout in a style which age seems to improve, though it is somewhat marred by a persistent and obvious egotism. The appendix contains a valuable synopsis of British Silurian fossils, enlarged to the state of knowledge at the date of publication, showing the range of each species, and referring in most instances to the original works where they are described. As already stated, the term "Primordial Silurian" is applied to all the fossiliferous beds below the Llandeilo; but I notice, that whilst some of the Tremadoc fossils are assigned to the Llandeilo, others are given to the Primordial, and that, evidently, not because the line of demarcation is drawn between the upper and lower Tremadoc; for we find *Theca Operculata*, *Niobe Homfrayi*, *Psilocephalus innotatus*, and other lower Tremadoc forms classed as Llandeilo, while fossils from the very same beds are put down as Primordial. The classification of *Calymene obtusa* as Primordial is surely a printer's error.

Referring now to the tenth edition of the "Principles of Geology," by Sir C. Lyell, I shall not attempt to enter into detail of the various alterations and additions which have made it to a very large extent a new work, because to do so at length would occupy not minutes but hours; and also because in the preface to each volume there is given a summary of emendations, with reference to the chapters and pages both of the present and the last previous edition. I shall therefore confine myself to exhibiting the views advanced by the author on two of the topics which are now prominently occupying the attention of geologists—the causes which have led to the great vicissitudes of climate, of which geological phenomena present such clear evidence; and that most *vexata quæstio*, "the origin and antiquity of man."

The facts upon which is founded the conclusion, that great changes in climate have occurred over wide areas, are given at length in chapters 10 and 11, vol. i.; and the causes of these changes discussed in the two following chapters. Pursuing a retrospective inquiry from recent times to those more distant, Sir C. Lyell concludes that in the bronze, or later stone age, to which the Danish kitchen middens and the Swiss Lake dwellings belonged, there is no evidence of any marked divergence from the present condition of things, the plants and animals then living with man being for the most part identical with those now existing. In the more ancient stone period, of which the flint implements are the chief human mementoes, "the enormous volume of the alluvial matter formed in the channels of old rivers, the contorted stratification of some parts of such alluvium, and the large size of many of the transported stones, imply a climate which generated much snow and ice in winter, and a mean annual temperature lower than that now found in the same parts of Europe." Mr. Prestwich estimates that the temperature of the vallies of the Thames, the Somme, and the Seine, was at this period 20° F colder than at present, or such as would belong to a country 10 to 15 degrees further north. "This estimate is founded," says Sir C. L., "on a careful analysis of the land and freshwater shells which accompany the remains of the Mammoth and its associates in the palæolithic alluvium."

Next comes the glacial epoch, of which our author remarks, "that evidences derived from the organic, as well as the inorganic world, conspire to establish the former prevalence throughout Europe of a climate now proper to polar latitudes." Again: after showing the great changes of level which must have occurred in Britain during the glacial epoch, he continues:—"Without entering in this

place upon the proofs of two Continental periods in Britain during the glacial epoch, separated from each other by a long interval of submergence, during which Great Britain and Ireland were in the state of an archipelago of small islands, it may be affirmed that the excessive cold lasted for a long series of ages, though not always with the same intensity."

Receding now a step farther into the past, when we examine the fossils of British Pliocene strata, we find in the earliest of them proofs of a climate warmer than that of England, and resembling that of the Mediterranean, "whilst in the uppermost or newest beds the fauna is quite Arctic." The same facts are exhibited by Pliocene strata of Italy. Again: "the 'upper Miocene' flora and fauna of the whole of Central Europe afford unmistakable evidence of a climate approaching that now only experienced in subtropical regions." At Æninghen, in Switzerland, Professor Heer has detected the leaves, fruits, and flowers of 500 species of plants, of which 131 might be referred to the temperate zone, 266 to a subtropical, and 85 to a tropical latitude. "In the present state of the globe the island of Madeira presents the nearest approach to such a flora." But the most remarkable of recent discoveries with respect to Miocene fauna is that of the same talented professor in Iceland, where in certain beds of lignite he finds "an assemblage of fossil plants closely resembling those of Æninghen, which, though not of so subtropical a character, indicate a temperature as much warmer than that now enjoyed in Iceland, as did the temperature of Central Europe then surpass that of the same region now."

Taking one more step back, we meet with still more striking proof of the existence, in times represented by lower Miocene strata, of a climate as far north as Spitzbergen, lat. 78° 56′, in which the hazel, poplar, alder,

beech, plane-tree, and lime flourished, where are now to be found scarcely any shrubs, except a dwarf willow and a few herbaceous and cryptogamic plants; most of the surface being covered with snow and ice. "We cannot hesitate, therefore," adds Sir C. Lyell, "to conclude that in Miocene times, when this vegetation flourished in Spitzbergen, North Greenland, and on the Mackensie river, and other circumpolar countries, there was no snow in the Arctic regions, except upon the summits of high mountains, and even then perhaps not lasting throughout the year."

A similar investigation is instituted for Eocene, and still earlier geological periods; but enough has been advanced for my purpose, which is to show upon so high an authority the nature of the climatal changes revealed by geological inquiry. The facts seem clear enongh; the causes are more obscure.

The ground traversed by our author in search of the true causes of such changes is very wide; and he strongly favours the conclusion *that climate is more affected by the distribution of land and sea than by any other cause.* At the same time he adds:—"The effect of the former variations in the heat and cold of different seasons of the year, caused by the precession of the equinoxes, combined with the revolution of the apsides, and still more by the variations in the eccentricity of the earth's orbit, will have to be taken into account as subsidiary to the more dominant influence of geographical conditions." In support of this conclusion, he shows first how widely the lines of equal mean temperature vary from that of latitude; the line of 32° F., for instance, running from 56° N. in Asiatic Russia to 70° in Norway; and again, the isothermal of 14° F. passes through lat. 62° 2′ N. in Siberia, and 79° in Spitzbergen, thus varying no less than 17 degrees. "The deviations of these lines from the same parallel of latitude

are determined by a multitude of circumstances, among the principal of which are the position, direction, and elevation of continents and islands, the position and depths of the sea, and the direction of winds and currents."

It is then shown that land situated between 45° lat. and the equator tends to warm the land or sea between it and the pole, because it is a better conductor than water of heat received from the sun; whilst land further north, especially when attaining a high altitude, has the reverse effect. In accordance with this reasoning, the greater cold of antarctic than of arctic regions is ascribed chiefly to the greater altitude and extent of the southern continent; and only a limited influence is attributed by Lyell to the eight days longer winter which there prevail, in consequence of the present condition of the southern hemisphere in regard to the precession of the equinoxes, and the eccentricity of the earth's orbit. The effect of currents in equalising temperatures is largely dwelt upon, as illustrated by the influence of the gulf stream upon our own climate, and that of more northerly regions; and the power of the polar current in the Atlantic is also shown by the fact that icebergs will drift south even against the wind and the northerly bias of the gulf stream; the colder current flowing below the surface, and having the greater influence from the fact that the bulk of the icebergs which lies below the water level is much greater than the portion which appears above the surface.

The present proportion of land and sea near the poles Sir C. Lyell considers abnormal, and speculates upon the vast changes in climate which would be produced by transferring the same area of land from high latitudes to near the equator; and in a lengthened argument maintains that in such changes of the position of land and sea lies the most potent cause of climatal variation. The late

President of the Geological Society of London, in his anniversary address, seems to favour the same conclusion; though, after reviewing various theories, he expresses no very decided opinion of his own. Sir C. Lyell notices at some length Mr. Croll's "Memoir on the Physical Cause of the Change of Climates," in which it is contended "that a maximum eccentricity of the earth's orbit would tend greatly to exaggerate the cold in that hemisphere in which winter occurred in aphelion; that consequently one hemisphere might be enduring the extreme cold of a long winter, whilst the other might be enjoying a perpetual spring." "Long previously, M. Adhémar had endeavoured to account for certain geological phenomena by a coincidence of winter solstice with aphelion, but without connecting them with the greater eccentricity of the earth's orbit, as Mr. Croll has done." Sir C. Lyell concludes that whilst our data are insufficient to decide to what extent the excess of ice thus produced would affect both the climate and sea level, he considers that we have here a "*vera causa*" of change hitherto neglected.

Elaborate calculations have been made to show the periods at which, under this theory, glacial conditions would recur; but after a careful review of them all, some of them specially calculated by competent astronomers at his own request, our author considers that the evidence afforded by the earlier Tertiary and older deposits, of very long and apparently uninterrupted periods, during which a much warmer temperature prevailed in our hemisphere, is strongly antagonistic to the adoption of the theory, except in connection with important changes of land and sea. The period required for the deposition of the coal measures alone he regards as more than sufficient for the lapse of several such cycles of eccentricity; but during this long period the conditions of climate indicated appear to be a

warm and moist atmosphere; at any rate, such as is quite inconsistent with extreme cold.

To the supposed variations in the temperature of different regions of space through which the solar system is travelling; to the gradual diminution of radiation of internal heat; to the theory of a change in the position of the earth's axis; and to Mr. Evans' new theory of the sliding of the crust over its fluid nucleus, Sir C. Lyell attributes little value. The impression left upon my own mind, after reading carefully Lyell's arguments and those of others, is, that the question as to the cause of climatal changes much resembles, in the present state of our knowledge, a problem involving five or six unknown quantities, towards the solution of which there is only one equation given; and that whilst all these speculations have their value, we are not yet in a position to adopt any conclusion which can safely be considered final.

As a necessary preliminary to the solution of the problem of the "origin of man," viewed from a purely scientific platform, Sir C. Lyell devotes several chapters to an examination of the various theories which have been propounded during the present century as to the nature of species and the mode of their production. He quotes from the edition of the "Principles," published in 1832, a lengthy *résumé* of Lamarck's ingenious theory, that all existing species have sprung from single monads, by a power of progressive development necessarily inherent in nature; and that varieties of form and organisation are due solely to the dominant influence of circumstances; including in that word the whole range of external influences which act upon the individual, whether plant or animal. Of course, man himself formed no exception to the action of this theory in the opinion of its author.

Sir C. Lyell admits that whilst endeavouring, in earlier

editions, to present a clear idea of this theory, he was entirely opposed to its acceptance, and "indeed did not venture," even up to 1853, "to differ from the directly opposite opinion of Linnæus, that each species had remained from its origin such as we now see it, being variable only within certain fixed limits." He also at that time favoured the idea of successive special creations of specific forms, gradually to take the place of species which became extinct, as opposed to the theory of some, that large assemblages of new forms have been ushered in at once at successive epochs, to compensate for the sudden removal of others.

The "Vestiges of Creation" was regarded by our author as so crude, and, in some respects, both so unphilosophical and so unscientific, that it exerted little influence in changing his views. The publication of "Wallace's Essay on the Law which has Regulated the Introduction of New Species," and Darwin's treatise on the "Origin of Species by Natural Selection," first shook his faith in the immutability of species. At great length he examines the evidence adduced in favour of these theories (which may be regarded as substantially one in principle), going into detail on the immense number of existing species; on the geographical distribution, and the migrations of plants and animals; the various causes of extinction of species, whether natural or produced by human agency; and also, as of great importance, the phenomena of insular flora and fauna. The vast array of facts thus marshalled is weighed by our author with great candour, and the mutual relations of all the various phases of this intricate question fully investigated; and though he nowhere announces in so many words his positive adhesion to Darwin's theory, it is quite evident that the overwhelming bias of his mind is towards an acceptance of it, and the

consequent abandonment of his old belief in successive creations, apart from ordinary generation.

The corollary question, whether, supposing the theory adopted for plants, and all the lower animals, man may, on any true scientific grounds, be fairly deemed an exception to it, is treated in a separate chapter; and, as might be expected, the author's previous unconditional acceptance of the conclusion that man has advanced from an original barbarous state to his present culture and civilisation; the close structural affinities which link man to the anthropoid apes, and through them with other forms of animal life of less cerebral development, preclude him from placing the genus "*homo*" in an altogether exceptional category from the rest of the animal world.

The Duke of Argyll's objection to Darwin's theory, "that after all it does not explain how new forms first appear, but only how, when they have appeared, they acquire a preference over others," is admitted for what it is worth; but is met with the reply that the real question at issue is "not whether we can *explain* the creation of species, but whether they have been introduced into the world one after the other in the form of new varieties of antecedent organisms, and in the way of ordinary generation, or have been called into being by some other agency, such as the intervention of a 'First Cause.' Mr. Darwin," adds Sir C. Lyell, "without absolutely proving the former of these, has made it in the highest degree probable, by an appeal to many distinct and independent classes of phenomena in natural history and geology." He then continues:—"When first the doctrine of the origin of species by transmutation was proposed, it was objected that such a theory substituted a material, self-adjusting machinery for a supreme creative intelligence. But the more the idea of a slow and insensible change

from lower to higher organisms, brought about in the course of millions of generations, according to some preconceived plan, has become familiar to men's minds, the more conscious they have become that the amount of power, wisdom, design, or forethought required for such a gradual evolution of life is as great as that which is implied by a multitude of separate, special, and miraculous acts of creation.

"A more serious cause of disquiet and alarm arises out of the supposed bearing of this same doctrine on the origin of man, and his place in nature. It is clearly seen that there is such a close affinity—such an identity, in all essential points, in our corporeal structure and in many of our instincts and passions, with those of the lower animals; that man is so completely subjected to the same general laws of reproduction, increase, growth, disease, and death; that if progressive development, spontaneous variation, and natural selection have for millions of years directed the changes of the rest of the organic world, we cannot expect to find that the human race has been exempted from the same continuous process of evolution. Such a near bond of connection between man and the rest of the animate creation is regarded by many as derogatory to our dignity. It certainly gives a rude shock to many traditional beliefs, and dispels some poetic illusions respecting an ideal genealogy, which scarcely 'appeared less than archangel ruined.' But we have already had to exchange the pleasing conceptions indulged in by poets and theologians as to the high position in the scale of being held by our early progenitors, for more humble and lowly beginnings; the joint labours of the geologist and archæologist having left us in no doubt of the ignorance and barbarism of Palæolithic man.

"The future now opening before us begins already to

reveal new doctrines, if possible more than ever out of harmony with cherished associations of thought. It is therefore desirable, when we contrast ourselves with the rude and superstitious savages who preceded us, to remember, as cultivators of science, that the high comparative place which we have realised in the scale of being has been gained, step by step, by a conscientious study of natural phenomena, and by fearlessly teaching the doctrines to which they point. It is by faithfully weighing evidence, without regard to preconceived notions; by earnestly and patiently searching for what is true, not what we wish to be true, that we have attained that dignity which we may in vain hope to claim through the rank of an ideal parentage."

In such eloquent language, and with true philosophical calmness, does Sir C. Lyell discuss the varied aspects and relations of the scientific problem as to "man's place in nature." The theme thus suggested is an inviting one; but this is neither the time nor place for its further discussion.

Upon the absolute age of the first traces of primæval man, but little fresh light is thrown in these volumes. As in the "Antiquity of Man," the flint implements of the river gravels of Amiens and other localities, to which must now be added various places scattered over the south of England, are regarded as the oldest known evidences of man's existence. They are mingled with remains of the Mammoth, the Norwegian Lemming, and other animals, indicating a much colder climate; and without any attempt to compute the date in years, are assigned to the close of the glacial period.

The President of the London Geological Society, in his late anniversary address, refers to the discovery of a human skull in a fresh-water deposit in Italy, which is

regarded by the geologists of that country as at the very base of the post-Pliocene formation, *and as carrying back man's existence into the true glacial period.* It would, however, be scarcely safe to accept this conclusion as absolutely demonstrated, until the relative age of the bed in which it was found has been thoroughly investigated.

In treating above of Lyell's views, I have simply endeavoured faithfully to epitomise them, so far as they differ from those previously published by him. I candidly confess that my own prepossessions are all strongly opposed to Darwin's theory; and that even on scientific grounds I am not prepared to accept it. At the same time, I freely admit that I have neither the fulness of knowledge of natural history, nor perhaps the ability for estimating the value of abstruse points of scientific evidence upon which the discussion turns, which would constitute me a competent judge in the matter. Upon a subject so intricate, and with such important bearings, I am content "to labour and to wait," as, after all, perhaps the most philosophical attitude.

So much more time than I expected has been occupied with these reviews, that I have but little space to notice other facts of geological interest. Before quite leaving the subject last discussed, I may remark, however, that Sir W. Hooker's address to the British Association at Norwich was little more than an elaborate illustration of Darwin's theory, derived from the facts of botanical science.

Amongst recent geological publications, the "Thesaurus Siluricus," or "Silurian Treasury," by Dr. Bigsby, demands notice. I have not yet had the pleasure of examining the work itself; but judging from the description given of it in the last edition of "Siluria," in advance of its actual publication, it must be of great value. It contains a list

of no less than 7,553 species of fossils found in Silurian strata, showing the geographical distribution of each; and we thus learn that some species had a range extending over Britain, Scandinavia, Bohemia, America, and even Australia. The duration of each species and genus, as evidenced by its occurrence in strata of different horizons, is also pointed out. Henceforth no student of Silurian geology can afford to be without this work.

We had also marked for notice Professor Heer's "Memoir on the Miocene Flora of Polar Regions," translated by J. E. Lee, Esq., F.G.S.; but some of the remarkable discoveries of this author were incidentally mentioned in treating of Lyell's views on climatal changes. It will suffice, therefore, to remark that we have unfolded to us the clearest evidence that in Miocene days, instead of the mantle of ice and snow which now envelopes these northern regions, and precludes the growth of any except the scantiest vegetation, there existed a temperature which nourished the giant Wellingtonea and its congeners; and along with them the beech, the chesnut, the plane, the oak, and poplar, with vines and ivy twining luxuriantly round their trunks, and a dense undergrowth of delicate ferns and shrubs. These plant-remains cannot possibly have drifted into their present position from any great distance, for along with the leaves are found the seeds, berries, fruits, and flowers, and the insects which fed upon them, entombed in a common grave. At the last meeting of the British Association, a report on the plant-beds of Greenland was read by Mr. Whymper, which probably contains further details of the geological record of the extinct flora of this region; but I had not the opportunity of hearing it read, and have been unable to meet with any published report of its contents.

Amongst the most interesting of recent discoveries

is that of Dr. Otto Torrell, also announced to the British Association at Norwich, of remains of plants in Sweden, in beds corresponding to the Lower Cambrian of our Longmynd series. The true age of the strata is attested by numerous competent authorities; and Sir C. Lyell, Professor Harkness, Mr. Carruthers, and other distinguished geologists and botanists, concur in the opinion that they are true plant-remains, belonging by no means to a very low order, being true monocotyledons, resembling the common flag of our rivers. They occur in strata apparently deposited in shallow water, as some of the beds bear rain-marks, as well as tracks of marine worms. We cannot suppose such plants to have been the only flora of the land, and consequently this discovery carries back our knowledge of the existence of land supporting a varied vegetation incalculable ages, and necessitates a modification of Sir R. Murchison's opinion, reasserted in the last edition with renewed confidence, that it was not until the close of the Silurian epoch that land plants first began to flourish.

The oldest plant remains absolutely recognisable as such, previous to this discovery, were in upper Ludlow beds, associated with the earliest fish; but I cannot help thinking that the flakes of anthracite found in the Longmynd rocks of our own country, and still more, the band of anthracite, ranging from one to twelve feet in thickness, reported by Mr. Jukes in lower Silurian strata in Ireland, and which latter Sir R. Murchison himself declares to be a true coal, are almost impossible of explanation, except on the assumption that they are of vegetable origin.

Whilst this long unsuspected flora of Cambrian age is thus being developed in Sweden, our honorary member, Mr. Hicks, continuing his successful researches in the vicinity of St. David's, has, during the past summer, brought to light, from beds which Professors Phillips and

Harkness admit to be unmistakable Cambrian, fossils representing no less than ten genera, including crustacea, brachiopods, pteropods, phyllopods, &c. Mr. Hicks' remarkable success in these hitherto barren formations elicited from Professor Phillips the assertion that so long as there was any trace of stratification, he should now never despair of finding organic remains. As Mr. Hicks' first paper was read before this Society, we are warranted in indulging some degree of pride in his success.

In another department of Palæontology also, our knowledge is enlarged by the discovery, in 1865, of no less than six species of neuropterous insects in Devonian rocks of North America; the earliest instance of land forms of animal life yet recorded. Before this, the Carboniferous beds were the lowest in which insect remains had been found, both in this country and in America.

Within the last fifteen months, two volumes of the admirable monographs of the Palæontographical Society have been issued. In the first of them Mr. Salter continues his beautiful delineations and careful description of Silurian Trilobites, chiefly illustrating the genera Ogygia and Illænus. Dr. Davidson also pursues his labours of love upon the Silurian Brachiopods, bringing out ten plates illustrative of numerous genera. Professor Phillips adds to our knowledge of Liassic Belemnites; and Dr. Duncan, on the same geological horizon, determines no less than forty-eight species of corals; whereas before only one or two species of Liassic corals had been accurately described.

The last named talented writer, who has devoted close attention to the study of fossil corals, recently announced, in the "Philosophical Transactions," that the genus Palæocyclus, which was supposed to link the Palæozoic to the Tertiary corallines, must be abandoned, and the form to which that name was given added as a new species

to Cyathophyllum. This determination, if confirmed, certainly robs our collections of some interest and value attached to the so-called Palæocyclus; but in all scientific matters truth, not fancy, must be allowed to rule.

In the last fasciculus of the Palæontographical Society we have a first instalment from the pen of our well-known and highly-esteemed Lancashire geologist, E. W. Binney, Esq., F.G.S., of a monograph upon the coal plants; a subject which, from years of attentive study, he is well qualified to illustrate. The genus selected is Calamites, or Calamodendron; for Mr. Binney contends that so far as his investigations of intimate microscopical structure have proceeded, the two are identical: the so-called Calamites being only the pith of the tree. Most beautiful figures are given, from sections prepared for the microscope with the utmost skill, of the structure of all parts of the plant —both the pith, the surrounding wood, and also the cone, which Mr. Binney is the first to show to belong to this genus. The Asterophyllites, which are determined to be the leaflets of the Calamodendron, are also figured. This is a most valuable contribution to our knowledge of carboniferous plants. We have also in the same volume part I. of a memoir on the fishes of the Old Red Sandstone, by Messrs. Powrie and Ray, Lancaster.

Before leaving the Palæontological province of our science, I must also call attention to the very interesting paper on Cambro-Silurian Brachiopods, in the July number of the "Geological Magazine," in which Dr. Davidson has figured and described most of the recent discoveries in this numerously represented family, both in North and South Wales.

Turning to the department of physical geology, we find the supporters of the rival theories of marine and atmospheric denudation maintaining the controversy with

unabated spirit, but I fear without proportionate direct benefit to science, as in some quarters the discussion is apparently carried on with a view rather to pick holes in an opponent's argument than to elicit and confirm the truth there may be in it. Instead of adopting exclusively one side or the other, is it not wiser to conclude that both marine and atmospheric agencies have played their part in producing the present outlines of land surface? Of the enormous erosive power of purely subaërial causes, the writer observed frequent striking illustrations during a recent short tour in Switzerland.

Mr. Geikie, the local director of the Scotch Survey, has recently presented the subject of "denudation now in progress" in a novel and suggestive light. Assuming the calculations of Messrs. Humphreys and Abbott, with regard to the sediment carried down to the sea by the Mississippi, as an approximate mean for the rivers of this country, and calculating the area drained by the Thames, the Tay, the Forth, and the Boyne, he arrives at the conclusion that probably the whole surface of the country is lowered by the detritus carried down by its rivers about $\frac{1}{6000}$ part of a foot in a year, or one foot in 6,000 years. Now the mean height of the Continent of Europe, according to Humboldt, is 671 feet, so that, supposing such a rate of denudation constant, and no counteracting force of elevation, Europe would be degraded to the sea-level in about four millions of years. Whether the figures here employed to illustrate the argument be correct or not matters but little; it is plain that we have here a mode of estimating geological time which, with carefully conducted experiments, may lead to valuable results.

I must now conclude. My only apology for the length to which my remarks have extended is the breadth of the field to be traversed. The limits of our science are

enlarging daily, not merely in one direction, but in many; and with every desire for brevity, I have been compelled to omit many subjects of interest. One lesson occurs to me from this review, especially appropriate to us as young geologists. Looking back over the history of our science, we find that its theories have undergone frequent change, and after the lapse of sometimes only a few years, their authors have been ashamed to own their intellectual offspring. Not so with facts; once established, they remain for ever, and we need not fear their growing out of date. Depend upon it, facts, not theories, are the true foundations of all science. I do not affirm that theories are always useless: on the contrary, they are often of the highest value; but only when they are the legitimate outgrowth of extended observation. Let us above all things then strive to be precise in our records of phenomena: let us beware of hasty theories, af too rapid generalisation, and especially of hypotheses founded on negative evidence, which last has been hitherto, I think, the great temptation and stumblingblock of the geologist; and if it be given us to add but a single stone to the temple of Natural Science, let us be thankful for that, remembering that it is only by becoming first the humble disciple of Nature that man has ever risen to penetrate her mysteries, or wield efficiently the sceptre of her power.

The following communication was afterwards read:—

NOTES ON THE GEOLOGY OF THE BREIDDEN HILLS.

By G. H. Morton, F.G.S.

This paper is inserted at the end of the volume, with a postponed communication "On the Geology of the Country around Shelve, in Shropshire," (read Jan. 14, 1868.)

NOVEMBER 10TH, 1868.

THE PRESIDENT, G. H. MORTON, F.G.S., in the Chair.

JOHN T. FORMAN, WILLIAM H. WILSON, and ANDREW STUART, were elected Members of the Society.

The following communications were read:—

ON THE GEOLOGY OF THE COUNTRY AROUND SHELVE, IN SHROPSHIRE.

BY G. H. MORTON, F.G.S.

This paper is inserted at the end of the volume, with a postponed communication "On the Geology of Shelve," (read January 14th, 1868.)

THE GEOLOGY OF THE NEIGHBOURHOOD OF INGLEBOROUGH. PART I.—SILURIAN.*

BY CHARLES RICKETTS, M.D., F.G.S.

THE Silurian rocks, which in this district form the basement upon whose eroded edges the Carboniferous Limestone rests, have been exposed by subaërial denudation in each of the dales; not only has the whole thickness of the Lower Carboniferous rocks been cut through, but the erosion has likewise extended deeply into the inclined and contorted strata of the Silurian formations.

In Chapeldale and Claphamdale they consist of a succession of unfossiliferous green slates and grits, considered to be of Caradoc age. In Crummackdale the Lower Silurian rocks are exposed in the anticlinal at Norber Brow at the

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* For a detailed description of the Silurian rocks, reference is directed to a paper by T. McK. HUGHES, F.G.S., of the Geological Survey, in the *Geological Magazine* for August, 1867, page 346.

entrance to the dale, and contain *Trinucleus concentricus*, *Phacops*, *sp.*, *Tentaculites Anglicus*, *Leptœna Sericea*, and other Caradoc fossils. Opposite the head of Wharfe Mill dam, the base of the Upper Silurian is exposed as a bed of conglomerate, the strata having been thrown down by a fault against the anticlinal. Upon it rests a bed of banded slate passing into thick beds of grits, which are exposed up the dale contorted into numerous folds. In Ribblesdale these beds are surmounted by dark blue ripple-marked flags and banded slates, having embedded in them calcareous nodules. They cannot be distinguished from the slates and flags of Llangollen, thus leading to the conclusion that these Horton flags and slates were deposited under circumstances identical with those of the Llangollen district, and, as *Cardiola interrupta* and *Orthoceras primævum* are prevalent organisms in each, their formation must have occurred in the same geological era, *i.e.*, they are of Wenlock age.

PART II —CARBONIFEROUS.

The Carboniferous rocks which enter into the formation of the Ingleborough Mountain, viz., the Carboniferous Limestone, the Limestone shale or Yoredale rocks, and the Millstone Grit, present a marked contrast to the highly inclined and contorted strata of the Silurian rocks, upon whose eroded surfaces they repose in a strictly horizontal position, excepting where the Carboniferous Limestone has been thrown down to the level of the Silurian rocks, by a fault running parallel to and dependant on the great Craven fault.

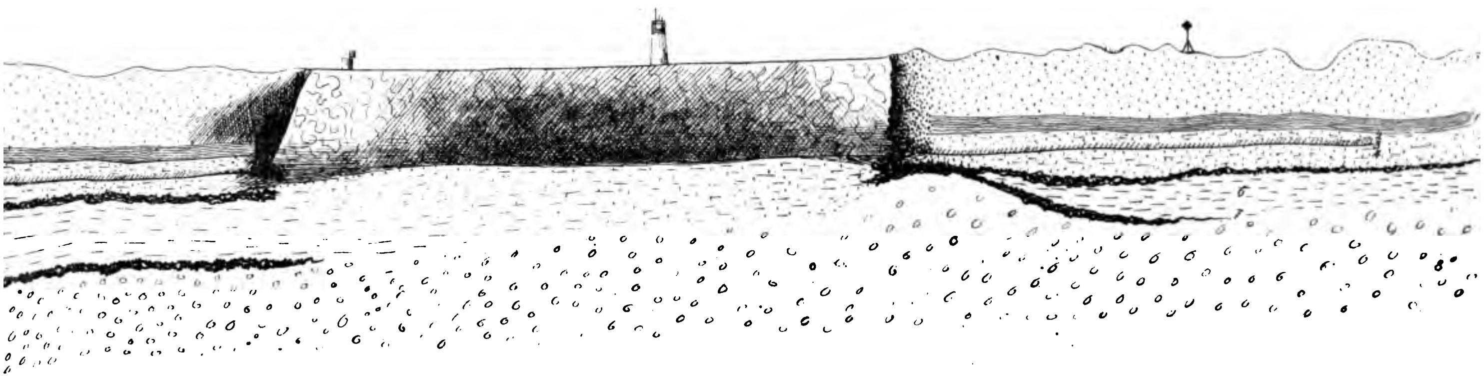
The peculiarities of the Carboniferous Limestone most deserving of notice are, a limestone conglomerate, having embedded in it Silurian pebbles, which occurs in many

places, forming the base of the formation, and the existence of a bed of impure coal, about two feet thick, exposed in the Ingleton limestone quarries. It has been formed upon an irregular surface of the limestone, probably indicating that upheaval and subsequent denudation has to some extent occurred previous to its deposition, and that therefore the present thickness of the Carboniferous Limestone, nearly 600 feet, does not represent the whole time during which the formation was in progress.

In the limestone shale is a bed of coal which has been worked in Whernside, but is not exposed in Ingleborough. There are also several bands of limestone, the uppermost being of considerable thickness, and composed almost entirely of stems of Encrinites. Of the Millstone Grit the base only remains, forming the summit of Ingleborough, but in Penygent, where the strata extend higher in the series, a bed of coal is found, of sufficient thickness to be worked. The great Craven fault can be readily traced from Settle by Clapham and Ingleton to Kirby Lonsdale, the extent of the downthrow being shown by the coal-measures which are worked to the south of the fault near Ingleton and Burton, the vertical displacement being, according to Phillips, not less than 3,000 feet.

On the limestone rocks of Norber Scar, at the entrance to Crummackdale, are numerous blocks of blue grit, similar to that which is exposed up the valley, being elevated at least 150 feet above the level of the beds from which they have been derived. Their presence in such a situation must be attributed to the action of glaciers, by which, in all probability, the chief denudation of these valleys, amounting to 1,800 or 1,900 feet, has been accomplished.

The more recent geological phenomena which abound in the limestone are caverns, swallowholes, potholes, &c.



HORIZONTAL SCALE 2 INS. TO A MILE.

1. Surface Soil.
2. Sandy Silt.
3. Fresh Water Bed
4. Sandy Silt.
5. Peat or Forest Bed.
6 Scrobicularia Silt.
7. Peat or Forest Bed
8. Purple Boulder Clay.

DECEMBER 15TH, 1868.

THE PRESIDENT, G. H. MORTON, F.G.S., in the Chair.

The following communication was read:—

OBSERVATIONS ON THE CHESHIRE COAST.

By CHARLES POTTER.

THE exposed portion of the Cheshire shore rests in a hollow of the New Red Sandstone. It is only as we approach the Dee on one side, and the Mersey on the other, that we come upon this rock, which crops out boldly in the neighbourhood of New Brighton and Hilbre Island. So far as we are able to judge of the surface, the boulder clay rests on the New Red Sandstone throughout the whole distance between the Dee and the Mersey, except where the Sandstone rises in rocky bluffs above the boulder clay in the beforementioned localities.

But whether the boulder clay rests immediately on the New Red Sandstone, or whether there are other beds intervening, is immaterial, as it is with the beds above the boulder clay that I have to deal in this paper.

Towards the Dee end of the embankment, which has been raised to protect the marsh from the sea by the Mersey Docks and Harbour Board, about midway between the Dee and the Mersey—(see diagram)—the boulder clay rises into what for explanatory purposes I shall call a boss. This boss, which rises but a few feet above the ordinarily exposed surface of the boulder clay, has had great influence on the superincumbent beds upon this shore, which, like all aqueous deposits that have formed around higher ground, thin out or entirely disappear on one side, to commence again at the same level on the other.

Bed 7, resting on the boulder clay, is a peat, formed of fresh water plants, principally "*Iris Pseud-acorus*" (L.), or an allied species. These plants are in a fine state of preservation through the whole thickness of the bed, and so abundant that it is scarcely possible to split off the thinnest flake without exposing many specimens. On the Mersey side of the embankment this bed must be looked for at a lower level than on the Dee side; in some places it is to be seen in outlying patches, the intermediate portions having been washed away by the sea. Trunks of forest trees are to be seen in it in larger numbers, mostly in a horizontal position. When the bed is of sufficient thickness these may be seen lying upon and crossing each other at every angle. There are also a few standing butts with outspread roots which have belonged to forest trees of considerable size. These roots and trunks are to be seen alike on the surface and in the base of the beds, in some places being even compressed into the boulder clay.

Resting on the lower peat is a silt, or bluish clay. (See diagram, bed 6.) Its dark colour may probably be traced to the presence of vegetable matter. This bed is entirely of *marine or estuarial character*. It varies considerably in thickness, being fully eight feet thick on the Mersey side of the embankment, and may be readily recognised along the greater portion of the shore by the presence of *Scrobicularia piperata*. In some places this bivalve is so abundant that I propose calling it the Scrobicularia bed. In other parts of it beds of *Rissoa parva*, and other common mollusca of our present shore, are to be found in a semi-fossil state, with more rarely a few bones of cetacea. Towards Hilbre Island I have found many bones of the horse, deer, ox, &c. In this stratum they are always detached and often broken. Many of the animals to which

these belonged may have perished in attempting to pass between the island and the main land.

The Rev. H. W. Croskey, of Glasgow, having examined some of the clay taken from this bed at a depth considerably below the surface, has detected with the microscope, in a semi-fossil state, about twelve species of estuarine or marine *Foraminifera* and *Entomostraca*, indicating climate and conditions similar to ours at the present day.

A short distance Deewards of the Dove landmarks the Scrobicularia bed lies immediately on the boulder clay, the lower peat bed having thinned out, or been denuded. Approaching the boulder clay boss towards the embankment the Scrobicularia bed thins out and the two peat beds nearly so, but landward the peats separate, and the Scrobicularia bed shows in considerable thickness, as may be seen in the indentations made on the shore front by the sea.

No. 5, a peat bed, is the most interesting of the strata upon this shore, from its varying thickness, and the mass of arboreal and other remains found in it.

Near the Dee end of the embankment a modern moss, containing *Sphagnum Palustre* in a spongy, half-decomposed state, has formed upon the older peat deposit.

Deeward from this the two peats are found to be only a few inches in thickness on the boss, and there they lose much of their vegetable character from incorporation with the Scrobicularia clay, whilst water-worn stones, which have projected from or lain on the top of the boulder clay, are to be seen through the whole thickness. Proceeding onward, the modern moss disappears, and the older and denser peat is of a tenaceous nature, cutting like soap, and of great weight. The upper portion of this peat bed, like the lower bed, is composed (although not to so great an extent) of the *Iris Pseud-acorus.* Having noticed that in the

lower part of this bed the Iris was entirely absent, I concluded that the marine character of the waters had gradually changed to that of *fresh*. Subsequent investigations have proved to my satisfaction that this theory, which I advanced during the Session of 1867—8, is correct. By digging down in the peat to the line of juncture with the Scrobicularia clay, I found that for fully eight inches of its thickness the clay and woody deposits had been going on at one and the same time, the *Scrob. piperàta* being found through the whole thickness in considerable numbers, but more plentiful in the lower than the upper parts.

That these marine shells lived and died on the spot, and were not thrown up by waves during a storm, is proved by the fact that they are all found with both valves united and erect in the beds with their posterior or siphuncular extremities uppermost.*

From the line where the arboreal deposits commence to give a character to the bed the clay and marine shells gradually disappear upwards, and the *Iris* as gradually takes their place, until it is impossible, as in the lower bed, to split off the thinnest horizontal laminæ without showing traces of it. In both beds the stems of this plant lie in a horizontal position, their roots and rootlets striking down perpendicularly into the beds below. The arboreal remains, which are to be found in such large numbers, I shall treat of hereafter. With the beds described the hollows in the boulder clay may be said to have shoaled out. Where they dip as they do opposite the Dove landmarks, it is owing to compression, and the beds to be described will not show that varying thickness which those below have done.

No. 4 is a sandy silt about nine inches in thickness, I

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* Lyell's "Antiquity of Man," p. 215.

believe of fresh water origin; but failing to find any organisms in it, I leave this to be settled by future investigations.

No. 3 is a purely fresh water formation, containing in great abundance the common fresh water shells which are to be found in our marshes and meres at the present time. This bed is of considerable extent, varying from four to eighteen inches in thickness. It is formed principally of decayed vegetation, has a black peaty appearance, although a little Deeward of the Dove landmarks there is a *patch*, where the vegetable character of the bed is lost, a stiff clay or silt taking its place. This patch is remarkably full of fresh water shells, and has, I believe, been deposited by the waters of a spring.

When the shore is tolerably free from sand the fresh water bed may be traced from the back of Great Meols to the embankment without a break; and again on the Mersey side it may be followed from the embankment for a considerable distance towards the Mersey, where it is invariably lost under the sand; two or three very thin seams of sand run through it, dividing it into pretty even layers.

No. 2. Above the fresh water bed is a sandy silt, which, like the sandy silt below, is probably of fresh water origin; but this too is devoid of organisms which would give it a distinctive character. Between the Dove landmarks and Meols a small seam of brick clay is to be seen when uncovered by the sand. It is but a few yards in length, and at the most six inches in thickness. A short distance inland from the shore this bed is sufficiently thick to be used for brickmaking purposes. The bed of brick clay is so seldom uncovered by the sand on the shore that I have not marked it on the diagram. Resting on this brick clay and the sandy silt below is the present land surface, No. 1. It is of an average thickness of about two feet.

From the embankment to Hoylake this bed or land surface bears evidence of long tillage; it is a very sandy, vegetable soil. In it are to be found, in large quantities, fragments of the edible mollusca common to our present sea shore. Many of these molluscs may have been collected and brought to their present position as an article of food by man. With these broken marine shells I have found three species of *Helix*, the latter being generally in better condition than the former. Mixed with these I have discovered Roman and mediæval remains. Although I have carefully sought I have never found a fragment of man's handiwork imbedded in any of the *lower* strata. I have picked up many pieces of Roman pottery, and other antiquities, from the surface of those beds, and collected a much larger quantity, which have been found by others; but I have no reason for supposing that a single specimen in my possession came from any other than the present land surface, from which they have been washed, and strewn by the waves over the lower beds.

I doubt not but prehistoric remains of man may be found down to the boulder clay, which forms the base of the beds here treated of. But I question if a single specimen of man's handiwork, within the historic era, or it may be within long ages before, has been, or ever will be, found naturally imbedded below the stratum forming the present land surface.

Of the sand-dunes I will say little. Many of them are of considerable antiquity. That they had encroached upon and covered the shore where we now see them previous to the reign of Queen Elizabeth is, I believe, proved by the fact that so very few relics of her reign, or of a later date, have been picked up on the shore, whilst in the rear of the sand hills they are to be found.

I will now offer a few remarks on the peat beds, or, as they are more commonly called, submarine forests. There was a time when I believed that the whole of the tree remains germinated, grew, and decayed, where we now find them; but whilst working up the materials for my paper on what had been considered as rootlets of forest trees and ancient sun-cracks in the surface of the Scrobicularia bed on the Cheshire shore (which the former supporters of that theory now admit are neither one nor the other), I accidentally came upon a small larch in a sound state, lying immediately under the bole of a large oak. Subsequently I found this was no uncommon occurrence. On the contrary, a very large number of these prostrate trunks are lying upon and crossing each other at every conceivable angle and depth in the bed; while the roots of the standing butts are as often above as below them. I had also observed that in the lower bed the standing butts and roots would not exceed ten per cent. of the prostrate trunks which are imbedded in it. These facts appear to have escaped the notice of those who had previously examined these beds, and led me in the first instance to doubt the correctness of my previous conclusions. I then determined to examine into, and satisfy myself on, the subject. These investigations have caused me to change my mind, and I give the following reasons for concluding that all the trees found in these beds have drifted from elsewhere.

There are many trees on this shore, the growth of which must have extended over one, or it may be two, hundred years. Yet these trees are not confined to any particular level in the beds, but are as likely to be found imbedded in the silt, either resting on the silt, or, if in the lower peat, directly on the boulder clay, as in the surface of the

peat beds. And yet, in no part of these is there any indication of vegetable earth, which has been formed under the influence of light and air; nowhere is there to be found the working of the common earthworm, which assists so largely in decomposing vegetable substances, and forming them into a friable vegetable soil. Everywhere the old peat beds are of a dense saponaceous character, with little or no signs of vegetable decay. If we take vegetable earth and rub it in the hand, when not too wet, it will pulverize. If we expose a lump in a damp state to frost, the expansion of the water in it will cause it to break up and pulverize on being thawed. But take a piece from these peat beds, especially where the trees are thickest, and rub it in the hand, and it becomes more and more tenacious. Place a lump on the surface of the earth, and light, air, and frost have very little more effect on it than they would have on a piece of old wood of the same size. Let the sea wash over its surface, and it is almost powerless to disturb it. The wasting action of the sea on those beds is almost confined to their front, which it breaks up into solid masses, but not until the underlying silt, or clay beds, have been washed away. And so tenacious are these detached masses, that where exposed to the full force of the breakers, they will remain for months as rounded nodules, like the sea-worn beach, and boulders that are derived from our hardest rocks. As I before pointed out, the fact that the horizontal trunks of the trees are found in the very lowest part, and through the whole bed, until they rise or project above the surface, is proof that they were being deposited during the whole period that these beds were being formed. Birch and larch, lying in the bottom, are likely to be sound from the core to the epidermis, whilst the oak and elm, either lying beside, across, or in any part above

them, are soft and rotten; and the reverse may be the case. Under any circumstances, these tree-trunks and boughs must have been covered up, whether grown on, or floated to, their present position.

Then, how are we to account for these different conditions of soundness, except that the one was more decayed than the other previous to imbedding?

Again, the standing butts have, in many cases, the prostrate trunks of trees lying immediately under them, whilst others spread their roots in every direction, on and above the horizontal trunks, and yet in no case do their overlying roots fashion or adapt themselves to those they rest upon. I have seen cases where they appeared to adapt themselves, but close examination proved that it arose solely from the pressure of the superincumbent beds; and most of the smaller roots and branches will be found to be more or less flattened from the same cause.

To my mind, one of the strongest evidences that these trees have not grown and been broken down where they now stand, is to be found in the fact, that although there are hundreds of trees exposed in these beds, not in a single instance does a prostrate trunk lie in such a position near a standing one as to suggest the idea that they might have formed one entire tree.

And while we have in a fine state of preservation the roots and rootlets of marsh plants which grew in the modern marsh and in the peat and silt beds before they were covered by the sand-dunes I, like others, have utterly failed to detect a single rootlet, either attached or unattached, or a leaf, which could be supposed to belong to a forest tree. Nevertheless, we have the smallest roots and twigs with the bark and epidermis preserved in the most perfect condition. In the epidermis of many plants

and trees, I am aware that Silex is present in considerable quantities, which would help to preserve them, whilst the absence of this mineral from the rootlets might allow of their more rapid decay.

But it must be borne in mind by those who argue in favour of these trees having grown where we find them, that those portions which have grown above the earth, as the branches, &c., would for a very long period lie exposed upon the surface, subject to the decaying influence of light, air, moisture, and insects, as at the present day, which would more than counterbalance the want of silex in the rootlets of the plants which are preserved, before a vegetable soil could possibly accumulate over them.

I have found on the Cheshire and Lancashire shore, in these peat beds, several large tree trunks, which had their upper portions buried deeply in *the undisturbed* peat beds, their lower or butt-ends projecting considerably above the surface. In the Hull Docks I observed a very large oak butt, with its outspread roots resting on the small end of an equally large oak trunk, the larger end of which appeared to be tilted by the weight of the butt resting on its opposite extremity. But the most convincing proof that these trees sunk through water into the soft bottom forming their bed, and had there been gradually silted up, was reserved for me in the forest bed at Selsey, in Sussex. Whilst exploring these beds in the company of Mr. W. Woodland, of Medmeney Farm, I found a tree butt of the usual length (about eighteen inches), in an undisturbed part of the forest bed. It was standing perpendicularly, the small end firmly imbedded, the root being upwards, and projecting above the surface of the bed. There may be a difference of opinion as to the standing tree butts on the Cheshire shore being in many places too

close together to have attained the size which they have done; yet I am disposed to believe that, by measuring and comparing these trees, especially the oaks, with trees of similar growth, it will be found that they *are* too close. Here also the oak, birch, &c., are found in close contact with the resinous firs; yet vegetation generally appears to shun the neighbourhood of the resinous firs at the present time.

Again: The standing butts which remain above the surface have such a natural appearance, that the superficial observer is almost certain to come to the conclusion that they are as they have grown. But on closer examination and digging out, they will be found to tell an entirely different tale. Whilst the roots of some through their entire length are perfectly sound, with the epidermis as fresh as in a living tree, others show decided evidence of having been exposed and weathered until their roundness and length were gone, and nothing remains but the hardest portions of the largest roots, and these show incontestable evidence of decay having reduced their once gigantic and rounded proportions to the sharpest angles and smallest fragments.

I question whether wood which has rotted under the soil, shut out from light and air, would in its decay leave the harder portions sharp and angular as are so many of these root remains. It is a state, I believe, which can only be brought about upon the surface of the soil. Again: How are we to account for nature having so completely reversed the order of growth from the earliest historic period to the present time? Forest trees require an elevation which will allow of sufficient drainage. The fir and other trees which are found in these beds will flourish on the mountain, but not in an undrained swamp; yet, if we

are to believe that these trees are in the position in which they grew, we must suppose that it was only one low level which was able to sustain and conduce to their growth. Wherever we find this peat or vegetable formation, we find its limits irrevocably fixed. Its surface, like the surface of water over a flooded country, reaches to a certain height on the rising ground which surrounds it. Beyond this maximum level it nowhere rises, and yet that maximum is the minimum of the present forest growth. If at the present time we plant saplings, or sow the seeds of forest trees, on a soil which improves in all the essentials required for their development as it recedes from the line up to which we have planted or sown, should we not find, in the course of time, that forest (unless kept back by the hand of man) extending its growth, and rising in greater luxuriance, as it stretched out beyond the arbitrary line up to which we had gone? But here we have nothing of the kind. The hard, impenetrable line, like that left by the receding flood, is nowhere broken.

No root, or stem, or well-preserved vegetable forms, which make up the thickness of these beds, go beyond this well-defined line; they do not, as we might suppose, creep up the gentle slope until they overtop the highest mountain, nor gradually die out at the height at which fructification could no longer be carried forward.

A local botanist having suggested that the cutting off of a portion of the standing butts, so as to expose the concentric rings, would show if the trees grew where they are now to be seen, by the thickening of the rings to the side exposed to the light during growth; I had about twenty cut, selecting the resinous firs in the upper bed, and in proximity to each other, as being trees less influenced than others by under growth. Amongst the twenty I found

trees which thickened to all the cardinal points of the compass. Two of these trees, within four yards of each other and surrounded on every side by more, showed a thickening of two-thirds in each to one side, the thickening of one being directly north, the other south.

Few persons can look on these prostrate trees, or what remains of the standing trunks, without the questions rising to their minds, What can have so completely cleared these trunks of their branches? Or broken off these mighty monarchs of the forest at their strongest parts?

These questions rose to my mind the first time I saw them; and after the most careful study I could only come to one conclusion—which was, that wind in combination with frost had been the sole agent. In this I have been confirmed by the following extract from a treatise by Dr. Mosely, who thus describes the effect of a tropical hurricane:—"The frightened animals in the field assemble together and are almost suffocated by the impetuosity of the wind in searching for shelter, which, when found, serves only for destruction; the roofs of houses are carried to vast distances from their walls, which are beaten to the ground, burying their inhabitants under them; large trees are torn up by the roots, and huge branches shivered off and driven through the air in every direction with immense velocity; every tree and shrub that withstands the shock is stripped of its boughs and foliage: plants and grass are laid flat on the earth; luxuriant spring is changed in a moment to dreary winter."

Can any person read this description of the appearance of a country after a hurricane without being at once struck with the resemblance that the prostrate trunks bear to it. Dr. Mosely says, "Large trees are torn up by the roots;" but not more than five per cent. of the trees in these beds

present the appearance of having been torn up by the roots, and of this number it is but very few that have any roots attached. The roots are cleared away from the boles, as the branches are from the trunks. The remaining ninety-five per cent. of the trees are broken off at one uniform level, and at the very strongest part of the tree. Dr. Mosely says, "Every tree and shrub that withstands the shock is stripped of its boughs and foliage." So accurate is this description of the appearance presented by the boughless trunks in these beds, that one might almost imagine the writer to be drawing his picture of desolation from them. Water has been suggested as the agent which may have risen, owing to a slight subsidence in the land, and rotted them off at the surface; but this cannot possibly be, if they grew where they are found, on account of the differing level of the same beds. Thus on the Dee side of the embankment there would be a difference of from four to six feet, whilst on the Mersey side the difference in the same beds would be much greater. Mr. Morton, at page 45 of his work on the "Geology of the Country around Liverpool," speaks of this forest bed being found thirty-five feet below high water mark of an ordinary spring tide, at the North Docks, near Bootle. As the forest beds at Meols are not covered ten feet by those tides, it follows that the trees at Bootle, about eight miles distant, should have been rotted off twenty-three feet higher up their trunks, after allowing two feet for the average height of the standing butts. It has been argued that the water has risen gradually on these trees, and that it has remained long enough to rot them all at the height at which they now stand. When it is borne in mind that we have oak, elm, and resinous firs (the latter being almost indestructible in water or tidal reaches) side by side with the larch and the birch, and that these destructible

woods show no signs of having been rotted or broken off earlier than the others, it must, I believe, be admitted that this argument will not hold good. But the strongest and most positive evidence is given against standing water being in any way the agent in breaking down these trees; in the few before spoken of, which have their boles or roots attached, these trees show no sign of decay in any particular part outwardly. Those who have looked on an old pile of wood, or a tree standing in the water, will have observed that decay goes on with the greatest intensity at the water-line from the outside (if the tree or pile be large), where many inches may be destroyed and gone from the surface, and more may be scraped away in a soft decayed state, and yet the middle remain perfectly sound. It has been suggested that insects are known to attack trees at certain heights, particularly the elms, thereby causing them to decay and break at the parts attacked, and that the breaking of these might be attributed to this cause.

The very different description of trees, and the enormous extent of country over which the beds containing these peculiarly broken trees are found will, I believe, negative such a supposition. But apart from the difference of trees and extent of country in northern Europe to which these beds extend, I know of few things which can be more readily detected than borings in wood which has afterwards lain under water, owing to the borings running, as they often do, across the grain, and getting filled with extraneous matter. Yet I have failed to find any borings except what have been made by the boring mollusca of a recent date; and these borings are entirely confined to the lowest parts of the beds seawards. One other fact which I have observed in trees which have been allowed to stand after they were dead for any considerable time is wanting in the trees found

in these beds: it is, that the bark separates from the wood, splits, and falls off, leaving the trunk and boughs white and bleached for a long time prior to the tree being so far decayed as to cause it to fall; but in most cases the bark remains fresh and firm on the wood, proving, I consider, not only that the killing of these trees was not by a slow process, but also that they did not stand long after they were dead.

I will now submit the theory which has suggested itself to my mind as the only means by which this most difficult problem can be solved; viz., that wind has been the direct agent, aided by extreme cold, which must have frozen the earth to such a depth that the wind has been powerless to uproot the trees; and, in consequence, the earth has been the fulcrum across which the breaking pressure has been exerted. Dr. Mosely, in speaking of tropical trees, says that enormous trees are torn up by their roots; and in any soil with which I am acquainted, I believe it to be impossible for either wind or water to snap asunder a large oak at its very strongest part unless the earth and roots were held together in one compact hard mass, and I know of nothing but frost which could accomplish this. As in a ship which is dismasted in a storm, the masts will break immediately below the crosstrees, or just above the deck, the deck forming the resisting power across which the masts are broken off, although it is the stoutest and strongest part of the mast, the earth, when ice-bound, would offer the same resisting power.

Let us imagine a storm coming on at a time when the earth is frozen several feet deep. The boughs are cleared from the stems, as they are shown to be at the present day by tropical storms. The storm increases in its intensity until the trees themselves, although standing as so many

bare poles, or ship masts, are borne to the earth, where for a long period of time they might remain protected by cold from decay or the ravages of insects. Storms of this kind may have preceded or accompanied those great physical changes in the boulder clay or drift formations.

Allow me to ask, have these beds received the attention to which from their vast extent they are entitled? It is not to this neighbourhood, as before stated, that they are confined; they are to be found alike over nearly the whole of the *low lands* of this country, and I believe I might add of northern Europe. Future investigations may, I believe, prove that these beds belong to the same widespread strata or system as those at Cromer, and place them low down in our Tertiary formations. In some places strata, which are observed below the so-called forest beds, are wanting; in others, the same with those above. But future investigators must prove whether strata which are found below in one place are *really* above in another, or the reverse. If not, those who believe in the principles laid down by "Strata Smith" will not, I suppose, wish to apply a different theory to these beds because they happen to be more recent than those he more particularly described.

Having made a personal examination of the beds in the Hull Docks, in which beautiful sections were exposed, I have no hesitation in saying that they belong to the same series, the same period of time, and were deposited under similar circumstances as the Lancashire and Cheshire beds. Should a perpendicular slice be cut from the Scrobicularia bed, the forest bed, and the purple or lower boulder clay in the Hull Docks, and be placed beside a similar slice taken from beds 6, 7, and 8, shown in my diagram of the Cheshire shore, it would require a very close examination to detect a difference in either their thickness, mineral, or organic cha-

racter. The arboreal remains are the same, they are broken in a similar manner, prostrate trunks are under roots, and roots are under trunks, the horizontal trunks in the base of the bed being as sound or sounder than the roots or trunks above. Finding the beds on the east coast similar to those on the west coast, the question arose to my mind whether the Norfolk beds did not belong to the same series? Judging from the description given of the organic remains found in those beds, as described in "Lyell's Antiquity of Man," and from the diagram given at page 213 of the 1863 edition of that work, in which two beds, viz., boulder clay and contorted drift are shown to hold a prominent position in the coast section of Cromer, in Norfolk, the lower boulder clay I consider may be identified with the lower of the two boulder clay beds forming the sea cliff between Hornsea and Bridlington.

And the contorted drift of Norfolk may belong to the upper or stratified drift of the Hornsea and Bridlington cliff, the contortions in the Norfolk beds being attributable to the local stranding of ice. I may here mention that on the Cheshire shore, directly at the back of Great Meols, in what is locally known as a gutter, contortions may be seen in the laminated silt forming the Scrobicularia bed No. 6. This bed has been forced up through the upper peat bed No. 5, and is twisted and contorted in an exactly similar manner to that described by Sir C. Lyell in the thicker beds of the Norfolk coast. It is very rarely that the contortions in the gutter or break are to be seen on the Cheshire shore, as it is mostly covered with sand. Not having seen the Norfolk beds, what I have advanced respecting them will be taken for what it is worth; but from my examination of the beds in the Hull Dock, and on the coast between Hornsea and Bridlington, I believe that the unstratified

drift forming the base of the cliff between Hornsea and Bridlington, and that resting on the Scrobicularia clay in the Hull Dock, are parts of one and the same bed.

I was informed by a gentleman who farmed land abutting on the shore between those places, that when the shore was free of sand, during very low tides, he had seen peat beds with trees standing in them like those in the Hull Dock, which he had also seen.

The submarine forests in the neighbourhood of Rhos, near Colwyn, described by Mr. H. F. Hall to this society, and published in its transactions for 1865-6, will, I venture to suggest, be found to correspond with the beds in the Hull Dock, as the drift, according to his paper, forms the cliff or sea front; and the position of the two forest beds, with the intervening silt, will, I doubt not, coördinate not only with the Hull beds, but with 5, 6 and 7 of my Cheshire coast diagram.

The forest bed of Selsey differs entirely in its mineral character from the beds previously described, they being formed principally of vegetable substances, whilst the Selsey bed is formed mostly of a very dark clay or silt, the dark colour arising from decayed vegetable matter. This difference between the beds on the south coast, as compared with those on the east and west, I attribute to those on the south coast having been deposited in water too deep or too salt to be suitable to the growth of the *Iris Pseud-acorus;* but here the arboreal remains are of the same description as in the beds on the east and west coast. Like those, the trunks are stript of their branches, and the trunks broken off at the strongest part of the tree—that is, at the surface of the ground in which they grew, or, at the most, a few inches above it. The bark still remains on most of the standing butts and horizontal trunks; and here, as in the

other beds, the horizontal trunks will exceed in number by almost ten to one, or perhaps by more, the standing butts.

Had the trees grown where we now find them, and the butts been in excess of the trunks, persons in favour of the theory of their having grown on the spot would probably have argued that the trunks had rotted away on the surface of the ground, or been swept away by floods, whilst the butts, being rooted to the soil, had resisted the floods, and all those portions below the surface shut out from light and air had decayed less rapidly. How are we to account for the reverse of this being the fact on any other grounds than that of their being water-borne; especially when we find horizontal trunks of large sound oaks lying in the bottom of the beds which have accumulated around and, it may be, several feet above? It is in the nature of roots to strike and penetrate below the surface of the earth, but it is *impossible* for a detached bough or trunk to do this. I have been asked how I could account for the rooted butts having the natural appearance which they have in these beds. To this I have replied, that the land on which grew the vast forests which have supplied these peat beds with their arboreal remains, may have subsided below the water in some such manner as the following.

These forests, being broken down by wind, and preserved by frost, as before described, would remain until the water flowed over the surface, carrying away, first the trunks, and then the butts; the roots of the latter having to be washed out of the soil before the water could float them.

The whole of these forest remains would drift until they were saturated beyond their floating weight, when they would sink steadily down; or they might be grounded by subsidence of the water, or by floating into shallows.

The trunks being broken off so close to the ground in which they grew, that portion attached to the butts has been left too short to influence their floating, or to tend in any way to overbalance them. They would in consequence float as they grew (rarely, as in the one at Selsey, turning over), and when they sunk by becoming too saturated to float, or grounded by the water becoming too shallow, the work of deposition would go on accumulating over and preserving them, as peaty deposits are known to do. The outspread roots would in that case have all the appearance of natural growth which so many of these exhibit.

By this theory we can account for roots being over trunks, and trunks over roots; also for the promiscuous crowding together of resinous and unresinous firs, oaks, elms, birches, beeches, &c., at one and the same level. To the same cause might be attributed the absence of rootlets and anything like decomposed vegetable soil, the thickening of the concentric rings to every point of the compass, and for the excess of trunks over butts. In no other way can I account for the different degrees of soundness and preservation of these tree remains, or for the total absence of forest tree leaves or their impressions.

If anything more were wanting to prove that these trees were deposited in water, it is to be found in the matrix in which the whole of the trunks and branches are imbedded, which is purely of aqueous origin, being principally of fresh water, but to a considerable extent estuarine.

The ocean is now clearing away the beds which I have described, and in countless ages hence some future antiquary or geologist may seek in another formation relics of our own time and those which have preceded us. In such a formation we have the difficulty of measuring time forcibly illustrated, for the relics of the present day will be

mixed up, or perhaps overlain, by those of Saxon, Roman, or prehistoric times washed from our present surface soil, or, it may be, very early prehistoric remains from the beds below. I cannot close these remarks without stating that I have found health and considerable pleasure in the investigation of these beds, and I trust to find much more. Better geologists may consider the time thus occupied wasted, standing as we do when on the Cheshire shore almost within the shadow of the grand old Silurian formations, those

"Relics of a former world,
"Medals of Creation's birth,
"Ere history her scroll unfurled,
"Or Man was tenant of the earth."

JANUARY 12TH, 1869.

THE PRESIDENT, G. H. MORTON, F.G.S., in the Chair.

ROBERT W. A. SCOTT, M.A., of Ormskirk, was elected a Member of the Society.

The following communication was read:—

THE NEW RED SANDSTONE AS A SOURCE OF WATER SUPPLY.

BY ROBERT BOSTOCK.

BELONGING as we do to that order of creation to whom fresh water is a prime necessity, it may not be wholly irrelevant to our studies as geologists to inquire from whence our present supply of this needful is obtained, and how those who may succeed us are likely to be situated as regards this matter.

Want of water seems to be a phase through which most large towns have to pass; nor is this peculiar to our own

time or country. In many parts of the world nearly all that now remains of towns and cities are the aqueducts or other contrivances formerly used for the conveyance of water, showing that the same privation was felt then as now.

The situation of Liverpool is somewhat peculiar, and as to water supply, may be considered very unfavourable—though this is scarcely realised as yet. But whatever the future of the town may be, it seems doomed for ever to draw its supplies from wells, which is a costly process, or from a distance, which is costly, and also a source of weakness. The latter mode has already been adopted to some extent; but all that can possibly be obtained from Rivington scarcely suffices for present requirements, so that this is a difficulty which must increase with time.

I will now direct your attention to the New Red Sandstone, premising that my remarks apply only to that in the vicinity of Liverpool.

It has been usual hitherto to regard this sandstone as a kind of natural reservoir, whose nature is to receive and store up vast quantities of water. One of our local engineers, who is also a geologist, speaks of sandstone as being saturated with water to fully one-third its weight. The Keuper Sandstone, you are aware, is frequently spoken of as "The Water Stone," from its being supposed to hold great quantities of water. To test this matter I procured specimens of all the varieties in this neighbourhood, selecting the compact, open-grained, and medium kinds of each. From experiment I find that the difference between thorough saturation and dessication is only seven per cent., the Water Stone or Keuper six and a-half, the flaggy varieties a trifle less; so it appears the utmost quantity of water sandstone can hold amounts to seven per cent. of its weight. Sand

and clay, of which soil is mainly composed, I tested in the same way, and found sand to hold twenty and clay twenty-two per cent. of water. How much of this it would part with, such as by drainage into a well, or how much would pass through sandstone in a given time, we of course have no means of knowing. But what presents itself for transmission in the shape of rain we will next consider.

The rainfall, as you are aware, varies with the situation, being greatest in elevated districts; around the coasts near the sea level it averages from eighteen to twenty-six inches per annum. In a paper read before the British Association at Norwich, by R. B. Grantham, he gave the average for seven years as 24·41, and the annual evaporation as 30 inches. It would not affect the conclusions I have arrived at if we supposed that the whole of the rain penetrated the soil; but as a reliable fact we know that it does not do so. Dr. Dalton's rain-guages were so constructed that whilst giving the annual rainfall, they also showed how much sunk into the soil to a depth of three feet. From observations of these for many years, it appears that it is only in the two first and two last months of the year that rain descended to that depth, the quantity varying from 11·29 to 26·61 per cent., according to the nature of the soil used and state of the atmosphere. Assuming the rainfall of this neighbourhood to be thirty-four inches, and that one-sixth penetrates the soil, the next step will be to try to ascertain how much of this could find its way into an ordinary well. To illustrate this I have drawn a diagram on a certain scale representing a well seventy yards deep, that being the greatest depth which can be or is likely to be sunk about here and be above sea level.

Supposing such a well as this, and the surface of the ground of a nature to allow of one-sixth of the rain

which falls being absorbed, it must be evident that that which falls nearest the well is most likely to find its way into it. I have taken five times the depth of the well, or a radius of 350 yards, as the limit of the drainage area; at that distance the angle between the bottom of the well and the surface is only 10°, consequently the friction would be so great as to prevent the passage of any from that, or at least any beyond that distance. A radius of 350 yards would inclose a space of about eighty-four acres. From calculations I find that—supposing the above area to consist of sandstone—at the rate of seven per cent. of water, the whole drainage area would contain 378,766,247 gallons. This quantity we may suppose present on commencing to sink a well, and of course would add considerably to the yield for some time. As this became exhausted, it would be dependent solely on the rainfall.

A fall of rain equal to one inch is equivalent to one hundred tons per acre. Allowing thirty-four inches as the annual rainfall, and supposing one-sixth of this to sink into the earth, it would give for the whole area 10,662,400 gallons, which would furnish a supply of 34,700 gallons per day for every working day in the year.

It will be understood that what has been said so far applies only to wells sunk in sandstone down to sea level. The per centage of water sandstone is capable of holding the quantity of rain which falls in a given space, and the proportions of this likely to drain into a well in twelve months. These data being given, one would expect that well-sinking either was or might be reduced to something like certainty. No doubt it might, only for certain disturbing elements, such as the surface being wholly or partially covered with clay or being built upon. Either of these would diminish the yield considerably.

The above is a description of a well sunk in sandstone to a greater depth than any in this locality, but still above the sea, also its yield, 34,700 gallons. Now as the wells hereabout, with one exception, are all less than seventy yards deep, all in sandstone; as the lowest yield of any is ten times more than the above, and the highest ninety times more; whence this extra quantity? Can their being sunk near the sea, and also below it, have anything to do with it? This brings us to the reason why I entered upon the present inquiry.

From my own knowledge of this district, more particularly the Cheshire side of the Mersey; seeing that the surface of the whole is a mass of clay, with a few sandstone bosses rising through it here and there, I had long thought that more water was raised from wells in this district in one month than the rainfall would supply in twelve. I suspected, too, where the extra quantity came from, but should probably never have taken any further steps, had it not been for the extraordinary drought we have just passed through. This served to clear away all doubt and uncertainty which formerly surrounded the question; and it now appears certain beyond all doubt—to me at least—that the bulk of our water supply is drawn from the sea, and that we are but little dependant on rain, as will appear, I think, from the following considerations. For the first nine months of last year the rain which fell in this part of the country was about seven inches.

Now I think it must be evident, allowing the highest possible estimate, that if our wells had been dependant upon rain they would have been dry for several months of last year. If a certain quantity of water flowed into a reservoir at one end, the same might flow out at the other without affecting the general level; but if the inward flow should

cease and the outward continue, from that moment the level would begin to fall. So with wells. If these were dependent upon rain, when it ceased raining last spring the water line in each should have gradually lowered; but instead of that, although there was an unusual draw upon them, they all maintained their general level.

Again: Whilst sinking wells about here it is usual to employ an engine to lift the water. As the shaft deepens this increases, so that it can scarcely be kept under. When this happens it is considered deep enough, and so it remains. Now it is an invariable rule that the point of greatest increase is below low-water mark. One of the public wells, when sunk to a few feet below Old Dock Sill, yielded 120,000 gallons per day. That being deemed insufficient, it was decided to carry it down twenty-five feet lower. For the last three feet the increase was at the rate of 30,000 gallons per day. How are we to account for this sudden increase? Throughout the district we have no instance of a well sunk above high-water mark yielding such results as this, nor of one below sea level in which there has not been a rapid increase below such line. As a contrast to wells near the sea, I may refer to a public well near Wolverhampton, in New Red Sandstone also. This consists of two seven feet shafts each 300 feet deep, a heading of 153 yards, and in this a boring of 390 feet depth. This, as regards depth, far surpasses anything in this neighbourhood; yet the yield, when just completed, was but 211,000 gallons per day. The smallest quantity drawn from any well in Liverpool was from the one in Bevington Bush. This in 1856 was 269,593 gallons per diem; but mark the difference in situation. Bevington Bush is within a mile of the sea, and but 104 feet above it, the bottom of the well being forty-five below ordnance datum. The one at

Wolverhampton is seventy miles from the sea, and near 500 feet above it. The inference seems clear.

From a glance at the diagram I have prepared of all the public wells about here, it will be seen that the water line never descends below the sea, whilst in several cases when not pumping it is many feet above. This additional height is no doubt due to rain, for when pumping commences this is quickly reduced, but never below a certain point. Now, if wells were dependant on rain alone, there seems no sufficient reason why the water line might not descend as far "below" sea level as it now is above it; but in practice it never happens so. The reason must be obvious. As regards three of the old wells, the water line is seen to be just above the datum level, and one a few inches below it. As all the land about these is now built upon, we may suppose they are not affected in any way by rain, but draw their whole supply from the river; and such will doubtless take place in others, if the town should extend so as to shut them out from the rainfall.

Possibly it may seem to you an objection to this view, that if our water is drawn from the sea it ought to be salt. How happens it that it is not so? This forms the subject of our next inquiry.

Well water is not quite free from salt, as may be proved by anyone who will taste the incrustation about a steam boiler in which well water alone is used.

The salinity of the sea varies somewhat, the highest proportion being about three and a-half per cent. In estuaries where there is much fresh water it is considerably less: about one and a quarter. From experiment I find that to render sea or river water drinkable it requires to be diluted with fifteen times its own weight of rain or fresh water; and even with twenty it differs very much in taste from spring water.

Sea water, besides the oxygen and hydrogen of which it is composed, contains no less than twenty-nine different substances. Whatever is soluble in rocks is dissolved and carried to the sea. Although all the requisites for chemical action are present none seems to ensue in the sea, for the saltness continues. Whether a chemical change takes place when the particles are divided, as they must of necessity be, whilst slowly filtering through sandstone, or other porous media, is not at present known; but it is a fact, that when sea or any other water, however impure, has undergone such filtration, it is deprived of its salt and other extraneous matter, not absolutely perhaps, but sufficiently so to render it potable. Such process, I think, the water in our public wells has undergone.

That the district around Liverpool, the bed of the river and its shores, is a mass of sandstone you are well aware; that water will percolate or filter through this you are equally well aware; but that such filtration deprives sea water of its salt you may have had no experience. We have evidence of this, I think, in the following cases.

I may state that these were not recorded for the purpose of supporting any theory, but are mentioned incidentally as singular phenomena, which everyone, of course, is at liberty to interpret to the best of their judgment; and whether you receive or reject the present paper, will depend entirely on your mode of accounting for this.

Humboldt, in his "Travels in Central America," speaking of the Archipelago of the Jardines and Jardinelles, off the Coast of Cuba, says:—"These little islands or shoals consist of fragments of coral, cemented by carbonate of lime, interspersed with quartz, sand, layers of sand and shells, and Madrepore coral. One of these little islets is but fifteen inches above the sea, basin-shaped, and in the

depression was brackish water; on some of the islands a little larger it was quite fresh."

Darwin, in his *Naturalist's Journal*, speaks of fresh water being found on Atolls or Coral Islands in situations which preclude the idea of its being rain water. The area of most of the Laccadive Coral Islands is not more than two or three miles, their elevation a few feet above the ocean. The surface soil in these islands rests on a crust of coral, beneath which is a layer or layers of sand. To obtain water, all that is requisite is to break through the coral to the sand, when fresh water wells up as fast as it can be removed. The water in many of these is influenced by the tides, and rises and falls with them.

The same with the Maldives. These are a group of Coral Islands stretching from Malabar to near the Equator some 500 miles—inhabited by nearly 300,000 persons, who depend entirely upon water thus obtained. The same phenomenon is also observed on the islands of Ceylon, and is described in Sir E. Tennent's work on Ceylon. This island consists entirely of granite, gneiss, basalt, magnesian limestone, coral, and sand. At the northern extremity is the peninsula of Jaffna, nearly severed from the mainland, having an area of about two hundred square miles. The highest part of this is about fifteen feet above the sea, not an undulation of more than a few feet to be seen. This part is composed of magnesian lime, sand, and coral, and a soil made up of the whole. The whole of this immense flat is in a high state of cultivation, carried on by means of irrigation with water obtained from wells. One of these, situated at Potoor, is very remarkable. This, which is more a cavern than a well, is 144 feet deep. For some depth the water is fresh; lower down it becomes brackish, then salt; moreover, it rises and falls a few inches twice every

twenty-four hours, being influenced apparently by the tide, though some distance from the shore. In the year 1824, the Governor, Sir Edward Barnes, caused an engine to be erected on this for raising water for irrigation; and although immense quantities were pumped up, it appears to have had no effect whatever upon it: it still rose and fell, and maintained its usual level. A short distance from this is another one in which the water is thirty-three feet deep, quite fresh and pure. Rains or drought or pumping never alters its level the slightest. This applies equally to all the other wells in the district. The November rains raise them for a few days, when they again sink to their usual level; and a drought of several years never depresses them below that of the sea. The same may be said of the wells on the Island of Malta; water may be obtained there by sinking to a few feet below low water near the shore, but in no other situation.

Now, the inference is, that in all the above cases the water has been rendered pure by filtration through porous coral, sand, clay, soil, &c. This is "one" of the natural modes of purification of sea water; but there are others. Marine animals and vegetation appear to possess the property of excluding chloride of sodium from their substance, for these are not necessarily more salt than those on land; and judging from the quantity of soda present in the Fucus or Kelp families of plants, it would seem as though these are capable of decomposing salt and retaining the soda. Evaporation is another mode. Whether owing to light or heat, the atmosphere, or all of them, or where the process is affected, whether before leaving the sea or after, we know not; but we are sure that rain water is derived from the sea, and we are equally certain that it is not salt.

But, in addition to these natural modes, it has been

proved by direct experiment that water percolating through a considerable mass of porous material is deprived of whatever it may hold either in suspension or solution, as described by Mr. Witt in the *Philosophical Magazine*. The effect of sand in ordinary filter beds is well known, and it seems very probable that sand is the principal agent in bringing about this change, for in each of the above cases it is mentioned as being present. Supposing it should be the case that sand and sandstone really possesses the property of rendering sea water fresh, the question arises as to whether it will continue to act thus throughout all time.

How many hundreds or thousands of years the Cingalese may have drawn water from the wells of Ceylon of course is not known; but Cosmas Indicopleustes, a merchant of Alexandria, who travelled in the sixth century, speaks of fresh water on islands off the coast of Taphrobane (Ceylon). He makes no attempt to account for it, but simply mentions the finding of fresh water in such unlikely situations as being very strange. So the same mode has been practised there for the last twelve hundred years at least.

That sandstone—like other rocks—has been subject to some chemical change you, as geologists, I think will admit. Seeing that it is a sedimentary rock, we are perhaps warranted in assuming that it has been laid down originally in much the same way we see the sandbanks in estuaries and elsewhere, and of a similar colour no doubt. If so, how are we to account for the present shades—yellow, brown, red, purple, green, and variegated sandstones—otherwise than by supposing it must have been by the percolating of water holding various mineral substances either in suspension or solution. Numerous actions and reactions must have occurred to bring about such a variety. The process which results in converting sea water into well water may

be of this kind. The silica, alumina, peroxide of iron, or all combined, may have the effect of neutralising the chloride of sodium or salt, and perhaps gives rise to other compounds.

There is nothing new in this idea of there being sea water in our wells. During the inquiry which took place in Liverpool, before Mr. Stephenson, in 1850, he and others gave it as their opinion that much of the water in our wells was derived from the sea; but there is this difference: with them rain was the principal, sea water a secondary consideration. I would reverse this, from what has been laid before you respecting the clayey surface of the country—the rainfall, and quantity which the earth absorbs—the per centage of water sandstone is capable of holding. This, coupled with the almost total absence of rain for the first three-fourths of last year, and the wells betraying no symptoms of failing, seems to make out rather a strong case in favour of that view which regards the sea as the main source.

During the same inquiry mention was made of several wells which on being deepened the water had become brackish and even salt. These must have been cases where a fissure had been cut, opening up a direct communication with the river or sea. The public well at Neston, one at Rock Ferry, Park Lodge, another at the Old Railway Station, Grange Lane, Birkenhead, are of this class. This is a contingency which no human foresight can guard against, and should always be taken into account. Sinking wells in this neighbourhood, as a rule, the nearer the sea the greater the danger from an irruption of salt water; but cases may be cited of wells close to or on the shore which are not thus affected—for instance, the Wallasey Well. This is within one hundred yards of the Great Float, and

the water in the well stands at the same level as that in the dock, but quite pure. Another one, at Messrs. Scott's Foundry, Tranmere. This is actually within and below the highest range of the tide. When made, some twenty-five years ago, it was sunk about ten yards in clay; but the water was brackish, and answered but indifferently for steaming purposes. A few years since a boring was made from the bottom through sand and clay to a depth of 64½ feet deep, then 4½ feet in the sandstone. A pipe inserted in this brought up water equal to that in the public wells. No particular care was taken in securing this pipe; moreover, it has been subject to the vibration of a suction pipe for seven or eight years; yet even now, although surrounded by salt water in the well, the water is still drinkable, and its freedom from salt or other matters may be judged of from the fact that the scale on a steam boiler using this constantly for three or four months is not thicker than a sheet of ordinary writing paper.

Anyone acquainted with the locality of either of these two wells would never for a moment suppose that rain had anything to do with their supplies. So it would seem to be a matter of indifference where these are placed; if a mile or so apart all the better.

I conclude by remarking that an apparently inexhaustible supply of water may be drawn from the sandstone around us. As the wells are all comparatively shallow, the water "may"—as in several it has—become impure through infiltration from the surface; but we have no experience of the supply failing, unless in the case of a neighbouring one being sunk to the greater depth. Though having said so much in favour of wells, I would not go so far as to say it would be advisable to rely solely upon them. I have never seen the Dee or Severn during their winter floods

without thinking what an advantage it would be if that water, instead of running uselessly away, was pent up in some of the upper reaches of the rivers, where land is of scarcely any value. By so doing a constant flow might be maintained throughout the year, and have sufficient left to supply half a dozen large towns. So, from an economical point of view, that would seem to be the preferable plan; but until Liverpool is in a position to go so far, it may be some little consolation to know that there is no fear of the wells becoming exhausted: a little more care would be requisite than has hither to beenthe case. There are not many, probably, who would think of sinking a well near a graveyard—for obvious reasons; but making a graveyard near a well would appear to be quite a different matter. However, through some strange oversight, several of our public cemetries have been formed certainly within the drainage area of the wells. Supposing we have nothing to fear from this on the score of health, the associations—to say the least of it—are rather repulsive. "In death I am with you" may be all very well in poetry; but none of us I fancy would care about realising this in actual life.

FEBRUARY 9TH, 1869.

THE PRESIDENT, G. H. MORTON, F.G.S., in the Chair.

CHARLES G. MOTT, JAMES ECCLES (of Blackburn), EDWARD WHALLEY, and GEORGE H. FLOAT, were elected Members of the Society.

The President exhibited a slab of New Red Sandstone from Wavertree—three miles from the Mersey—exhibiting well-marked ice striations. He stated that the exposed striated surface was about fifty square yards, the direction of the striæ being twelve degrees W. of N.

A paper, entitled "Notes on the Arenig Rocks in the Neighbourhood of St. David's," was read by Mr. R. A. Eskrigge, F.G.S., who prefaced it with a brief account of the distribution of the Arenig Rocks in Britain and elsewhere, giving also the order of their discovery, with a list of their chief characteristic fossils, and showing their relation to the rocks above and below them.

NOTES ON THE ARENIG ROCKS IN THE NEIGHBOURHOOD OF ST. DAVID'S.

By Henry Hicks, F.G.S.

Though the upper members of the Llandeilo formation present in the neighbourhood of St. David's, as well as their fossil contents, have been well known for many years, and were even mentioned in the *Silurian System*, published in 1838, the lower portion, or that now known as the Arenig Rocks or Skiddaw Slates, has been recognised only within the last few years. Up to 1863 only some two or three species of fossils had been discovered in these beds, and much doubt then existed as to what part of the Llandeilo formation the beds belonged to. However, the researches carried on since then by myself, along with occasional valuable assistance from my friends, Messrs. J. W. Salter, R. Lightbody, R. A. Eskrigge, and D. Homfray, have cleared up all doubt as to their true position, and we are now able to correlate them by the fossils with the Skiddaw Slates, so well known through the labours of Prof. Harkness and Dr. Nicholson —the Arenig Rocks of North Wales—and also with strata in the Shelve district well known to all members of this Society, through the interesting papers communicated to the Society by Mr. Morton. These researches also have been the means of discovering an entirely new set of beds,

underlying the others, and with a fauna wholly distinct. This fauna, however, approaches in many respects that of the Arenig in character, but is peculiar in not possessing many of the characteristic Arenig genera, and in possessing others hitherto unknown in those rocks. The true Arenig or Skiddaw Rocks, wherever found, as also their representatives in America, Australia, and the Continent of Europe, are always characterised by containing an abundance of graptolites; but these St. David's beds, so far as we at present know, contain none. These beds, moreover, rest conformably on Upper Lingula Flags, and retain much of their lithological characters. They seem to graduate by insensible degrees from the Lingula Flags, first as bluish-grey slate, and then earthy grey thick-bedded rock of a peculiar tough texture, to attain at last the black shaley appearance of the overlying true Arenig beds.

In consequence of their position directly upon the Upper Lingula Flags, and of the absence from them of graptolites, oeglina, ogygia, and other Arenig genera, Mr. Salter and myself, in our report to the British Association in 1866, classed them as Tremadoc Rocks; but since then we have thought it best to include them in the Arenig group, finding that the majority of the genera are more nearly allied to those in the latter group than to those in the Tremadoc Rocks. But withal there is no doubt that they occupy here relatively the same position as do the Tremadoc Rocks in North Wales, being as it were the intermediate series between the Primordial zone on the one hand, and the Llandeilo formation on the other. Mr. Salter and myself have now proposed to classify these as *Lower* Arenig Rocks, as distinguished from the Upper portion or true Arenig Rocks.

These beds have a thickness of about 500 feet, and are

to be found at several spots in the neighbourhood of St. David's, viz.:—Ramsey Island, Whitesand Bay (north-side), and at Llanverran, also about seven miles inland, at a place called Tremanhire. Wherever found they are invariably rich in fossils, many of the beds seeming to be almost a pure mass of organic remains. Up to the present time about 20 new species have been discovered in these beds, comprising *Homalonotus*, 1 sp. (the earliest yet found); *Calymene*, 2 sp.; *Asaphus*, 4 sp.; *Orthoceras*, 2 sp.; *Nucula*, 2 sp.; *Bellerophon*, 1 sp.; *Orthis*, 2 sp.; *Lingula*, *Obolella*, an *Encrinite*, &c. And it must not be supposed that this is the limit of the fauna, for much yet remains to be done for these beds before they will have been satisfactorily examined. The Brachiopoda were figured and described by Mr. Davidson, in the *Geological Magazine* for July, 1868, but all the other species still remain to be done.

The Upper Arenig, or the Black Slate Series, which we look upon as the true representatives of the Arenig and Skiddaw rocks as previously known, are also exposed at Ramsey Island and the north side of Whitesand Bay, as well as in the neighbourhood of Aberiddy Bay, where they underlie other members of the Llandeilo formation. The thickness of strata is considerable, and though they are somewhat less richly fossiliferous than the underlying series, yet numerous species have been found in them. Graptolites now begin to prevail, and the genera *Oeglina*, *Ogygia*, and *Trinucleus* come in. About 21 species have already been discovered, and all, save, perhaps, one or two of the Brachiopoda, are entirely distinct from those in the underlying beds. They comprise Graptolites, 3 or 4 sp.; *Oeglina*, 2 sp.; *Ogygia*, 2 sp.; *Asaphus*, 1 sp.; *Trinucleus*, 2 sp.; *Ampyx*, 1 sp.; *Agnostus*, 1 sp.; *Calymene*, 1 sp.; *Bellerophon*, *Orthis*, *Lingula*, *Theca*, *Orthoceras*, and

Siphonotreta. A few of these species have already been described, viz.:—*Trinucleus Gibsü*, *Oeglina grandis*, *Ogygia bullina*, *Ogygia peltata*, and the *Brachiopoda*, but all the others, like those from the Lower beds, have yet to be figured and described. Combined, they really form a very rich addition to the fauna of the Arenig rocks.

It is evident from differences in lithological characters, that the upper and lower Arenig Rocks in this neighbourhood were deposited under somewhat differen tconditions. The lower Arenig Rocks, which certainly seem distinct from any hitherto found elsewhere in Britain, are often gritty in character, and must have been deposited under somewhat shallow conditions. The upper Arenig, on the contrary, being usually a tolerably fine slate or shale, must have been deposited in deep water—the former when there was but a gentle depression of the sea bed, the latter when a very decided depression had taken place.

The following communication was also read :—

PALÆONTOLOGICAL OBSERVATIONS ON THE CARBONIFEROUS LIMESTONE IN FLINTSHIRE.

By G. H. Morton, F.G.S.

The Author gave a description of the Mountain Limestone of Flintshire, and proposed the following division of the formation :—

Upper Mountain Limestone......... (Yoredale series).	150	ft. thick.
Lower Mountain Limestone.........	1000	„ „
Total	1150	„ „

The Upper Mountain Limestone consists of strata,

mostly of a black colour, interstratified with beds of shale. The highest beds contain silicious concretions, and are covered by solid strata of chert, which pass upwards into the Millstone Grit.

The Lower Mountain Limestone is composed of strata which are usually of a light grey or buff colour. The highest beds are very arenaceous, and the base of the formation is interstratified with brown sandstones containing the remains of plants.

The Palæontological results are remarkable, for the preponderance of certain fossils is amply sufficient to identify the position of the strata—whether in the upper or lower subdivision.

In the list of the fossils collected by the Author there are 67 species. Of these 24 species have, so far, been only noticed in the upper subdivision, 31 species only in the lower subdivision, while 12 species are common to the whole of the Mountain Limestone.

From these observations it is obvious that there is a decided difference in the species that are of common occurrence in each of the proposed subdivisions, even supposing that a greater number should hereafter be found to occur in both. When the Author's investigations in Flintshire are complete the detailed results will be communicated to the Society.

MARCH 16TH, 1869.

THE PRESIDENT, G. H. MORTON, F.G.S., in the Chair.

The following communications were read:—

ON THE CHEMISTRY OF THE PRIMÆVAL EARTH.—(INTRODUCTORY PAPER.)

BY NORMAN TATE, F.C.S.

THE object of this paper is to bring before the Society some of the most important facts interesting to geologists, which were touched upon during the late discussion between Dr. Sterry Hunt and Mr. David Forbes, and also to point out some other matters which I think should be taken into consideration in studying this subject. Owing, however, to the large number of facts and opinions involved in the discussion, the present paper is only a preliminary one, bearing more especially upon theories advanced in reference to that part of the world's history from its earliest condition to that stage when it first became possessed of a solid external crust or surface, and an ocean.

This subject may be considered under the following heads:—

Advantage to be derived from the inquiry.—This subject, embracing as it does so wide a field of inquiry, and the consideration of nearly all known phenomena, is one affording excellent ground for the generalisation of ascertained facts, and eminently calculated to suggest new and more extended lines of research, which must add greatly to the already bountiful harvest garnered by science. Further: there is in it a certain amount of attraction which is of service, inasmuch as it affords opportunity for that judicious indulgence of the imaginative powers of the mind that give a zest to the collection and arrangement of knowledge, which, of itself, is often dry and unpalatable. The inquiry must of necessity be to a very great extent speculative, and speculations, unless grounded upon facts, require to be used with the greatest caution in scientific inquiries.

Nevertheless we may, by judiciously indulging in hypotheses, gain much advantage; for I hold with a writer of the present day that, although "these speculations may be dreams and nothing more, yet a little dreaming is good for scientific progress, provided the process of dreaming is not vainly conceived to be a process of proof." Therefore, if we consider, as I think we must—for the results of scientific investigation seem more and more to force us to such a conclusion—that causes now in operation are sufficient to account for the production of our globe; if we are willing to "study effects in order to arrive at causes;" if we feel that the "relic is to the past as is the germ to the future;" and that "each material form, could we rightly read it, is a book containing in itself a past history of the world," we may, by bringing together facts already ascertained, and by entering into further researches suggested during the inquiry, gain much advantage in the study of the Chemistry of the Primæval Earth.

Limit of the inquiry.—In order that we may see what is and what is not required for the complete consideration of the subject, we ought to commence our inquiries at the earliest possible point. There is, however, a limit—a barrier impassable—which I most distinctly acknowledge, viz., that however far back we pursue our investigations, we must at last arrive at a point beyond which we are totally unable to point to any antecedent but the will of a Creator. Therefore, such would be my answer to the first question which suggests itself in the inquiry, "How and from what did this earth originate?"

The nature or primary condition of the matter of which our globe is composed.—This is the next question which suggests itself, and it is one which I think we may legitimately consider. Believing that by what is known as the

nebular hypothesis, all the leading phenomena of the solar system and the heavens in general are explicable, I take that hypothesis as a starting point. The discovery of spectrum analysis afforded new power of observation with reference to this hypothesis, and scientific men eagerly availed themselves of this new method in order to support their views for or against this theory. I feel myself compelled to admit that the results so far obtained by spectrum analysis and other improved methods of observation of the sun, planets, and fixed stars, are very greatly in favour of the nebular hypothesis. Still it is necessary to proceed with great caution, and not jump too hastily to conclusions.

I may express the results obtained when I say that spectrum analysis, aided by telescopic observation, shows that there exists in space matter of different degrees of attenuation, extending from a state of glowing gas to bodies like the earth and the other planets which revolve round the sun.

It has been pointed out that, although in the sun, fixed stars, and planets, we are able to note with tolerable certainty the existence of many bodies which exist on our earth, yet there are many others we are acquainted with, which we cannot detect in these heavenly bodies; and further, that the nebulæ afford only evidence of hydrogen, nitrogen, and perhaps of some unknown substance of even more elementary character than hydrogen, which is the most elementary we are acquainted with. Therefore it is argued that there is not sufficient evidence of a common origin such as the nebular hypothesis would have us suppose. There are, however, some facts which must be taken into consideration on this point. The results of the observations of Mr. Huggins and others go undoubtedly to prove that there exist amongst the nebulæ bodies of a

gaseous character. Now, the experiments of Drs. Plucker and Hittorf (See Philosophical Transactions of the Royal Society for 1864), show that, whatever may be, under certain circumstances, the practical importance of prismatic analysis in detecting certain substances converted into vapour, whatever may be its use in indicating traces of a single gas imperceptible by other means, mixtures of permanent gases are not fitted to be examined by the prism. A gas, if mixed in rather small proportion with another gas, entirely escapes observation. The proportion necessary to render it visible depends upon the nature of the gas as well as upon the temperature of the flame. Then, again, highly transparent bodies, such as gases are, emit when heated but a feeble light compared with that which would be radiated, at the same temperature, by more opaque bodies. And it must also be remembered that there is a certain number of elementary substances which, when differently heated, furnish two kinds of spectra of quite a different character, not having any line or band in common. Further investigation will probably enable chemists to meet the difficulties which are thus presented.

There are likewise many considerations which compel us to take into consideration the possibility of the existence of a still more elementary form of matter than any we are acquainted with, and that such matter may exist in the nebulæ and other bodies in this more elementary form. We are compelled to confess that the results of chemical and physical investigation tend to show the possibility that at some future time, by the aid of new or improved methods, the now so called elements may be resolved into other and simpler forms of matter.

Certainly the history of chemical discovery shows that new methods of research have tended to increase the

number of so-called elements, but at the same time they have given better means of examining their properties, and have afforded sufficient evidence to warrant the supposition that these elements are only so many different forms of development of one simple kind of matter. In reference to this part of the subject the author referred particularly to the opinions of Professor Graham (see Royal Society Transactions, 1864), the late Professor Faraday and others, and then proceeded :—

We must however leave the nature of primary matter as a question we are totally unable to solve at the present time, and probably we shall never know its actual condition, but there is, without doubt, much evidence to warrant the conclusion that the matter constituting our earth was once in a vaporous state.

Manner of Condensation :—From this vaporous condition we suppose that by gradual subsidence and condensation it has assumed its present form. After mentioning the various theories which have been put forward on this point, the author alluded to the view supported by Dr. Sterry Hunt, that the earth is essentially solid to the core. This view is principally supported, first, by the consideration of two astronomical phenomena, the precession and nutation, respecting which Mr. Hopkins, in papers in the Philosophical Transactions for the years 1839, 1840, and 1842, by mathematical analysis, arrived at the conclusion that the solid crust of the earth must not be less than 800 or 1,000 miles thick. Then again, Professor William Thomson, in his Memoir on the Rigidity of the Earth, believes it to be extremely improbable that any crust thinner than 2,000 or 2,500 miles could maintain its figure with sufficient rigidity against the tide generating forces of the sun and moon to allow the phenomena of the ocean

tides and of precession and nutation as they now are. Archdeacon Pratt also is supposed to have proved that a thin crust, such as 25 to 100 miles, could not withstand the crushing effect of immense mountain masses, such as the Himalayas.

Then again are brought forward the experiments of Hopkins and Bunsen, which show that the fusing points of certain bodies are raised when under pressure, and it is consequently assumed that the enormous pressure exerted upon the matters constituting the interior of our globe must necessitate a solid state.

Principally upon these four considerations I think the theory of a solid globe is based.

With regard to the phenomena of precession and nutation, and the arguments based upon them by Mr. Hopkins, a paper in the *Geological Magazine* for November, 1868, p. 507, by Mr. Delaunay, very satisfactorily demolishes the theory constructed by Mr. Hopkins, and others, and shows the fallacy of purely mathematical reasoning in such cases; and as the theory of Mr. Hopkins fails when subjected to the test of experiment, I am less disposed to subscribe to the conclusions of Professor Thomson and Archdeacon Pratt, which are also based too entirely upon mathematical considerations; for I can understand such a thing as placing too much reliance upon mathematics in such matters as we are now considering, and, to use words once employed by Faraday, "it is quite comfortable to me to find that experiment need not quail before mathematics, but is quite competent to rival it in discovery;" and when we are tempted, whilst pursuing Geological inquiries, to rely entirely upon mathematical calculations, we shall do well to bear in mind the pithy remarks of Professor Huxley (Anniversary Address to

Geological Society of London)—"Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but nevertheless, what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data."

With regard to the experiments on fusing points under pressure, I am certainly somewhat surprised to see so much stress laid upon them, and I do not know that I ever met with greater deductions based upon more slender data than we have exhibited in taking these experiments as evidence of the solidity of the interior of our globe. (These experiments were referred to at length.)

With a globe solid to the core, or with a crust of a thickness of 800 or 1000 or 2000 miles, it is very difficult to explain the phenomena of mountain chains, continents, seas, and volcanoes. Taking only volcanoes, the phenomena presented by them afford very strong evidence in favour of a fluid nucleus or zone at no very great distance from the surface. Professor Hopkins indeed seems to have found a difficulty with reference to volcanoes, and, in order to get over it, assumes what to me seems very improbable, that there are isolated lakes of molten matter enclosed in the thick crust he supposes to exist, and situated not very far from its surface. But the remarkable agreement in character in various parts of the world of all the products of volcanic action points very strongly to the existence of a common origin. It has been argued that chemical decompositions taking place beneath the surface are sufficient to account for volcanic phenomena; but so far as facts furnish us with

information I am of opinion that we are not justified in ascribing the production of volcanic phenomena to purely chemical action.

We have much evidence that there is an increasing temperature as we go from the surface towards the centre of the globe; and although the evidence of this internal temperature requires to be still further tested by more complete and extended investigation, yet it can scarcely be doubted that the interior of the earth is much hotter than the surface; therefore before we can give adherence to the view that the earth is solid to the core, I think we must wait to be shown that intense pressure exerts a greater influence in producing solidity than does the intense heat in causing liquidity.

The chemical changes supposed to have taken place during the condensation and consolidation of the earth were afterwards alluded to, the author generally supporting the views put forward in the late discussion by Mr. David Forbes, and stated that the various phenomena he had noticed during long experience in smelting operations, chemical and other manufactures, and in ordinary analytical processes, compelled him to object to most of the views held by Dr. Hunt, and he gave illustrations of reactions which were proven to take place in the manufacture of certain kinds of glass in support of Mr. David Forbes's views.

The consideration of the origin of granites, limestones, &c., referred to in the late discussion, was reserved for future papers.

ON THE WELLS AND WATER OF LIVERPOOL.

By Isaac Roberts.

From what source does the Red Sandstone in and around Liverpool receive its supply of water?

That is the question which I propose to answer in the following paper; and let me here note the fact with due respect, that the expressed views of some members of this Society appear indefinite and somewhat confused in reference to this question. They still adhere to a theory that the source of the water found in the sandstones of Liverpool is in some distant places, such as the hills of Wales or of Cumberland, and that the water is conveyed thence to Liverpool through mysterious channels deeply formed under ground into the wells and bore holes which may be made to receive it.

To disprove this theory, and to endeavour to establish clearer views of the subject, I shall first call attention to the Red Sandstone as seen under the microscope—then to the laws of hydrostatics; and, lastly, to the chemical composition of the water in the River Mersey and water taken from several of the wells in Liverpool.

The microscopic appearance of the Red Sandstone may be described as follows:—It is an aggregation of hard grains, chiefly quartz—many of them roughly rounded and scratched—many are crystalline, with the angles unbroken; the faces polished like glass and semitransparent; and all the grains are attached to one another by a siliceous cement at every point of contact. Most of the grains are white, others are coloured red, blue, and black, and attached to each grain of which the stone is composed, are other much finer grains, having the appearance of white and red dust, even when viewed under a moderately high magnifying power. A bottle full of dry peas would give a fair illustration of the appearance of a piece of the Red Sandstone when magnified about forty diameters under the microscope. Each pea would be in contact with six or eight of the adjoining peas; but as each one is globular,

the spaces which the angles would have filled if the peas had been square are vacant; and the collective extent of the vacancies might be estimated by noting the quantity of water which the bottle would take in after it had been filled with peas.

This illustration is intended to show what takes place when water comes in contact with the sandstones. If a block of the stone be partially immersed in water, it will be seen that the water will rapidly rise in it by capillary attraction. It does not rise by being *absorbed into* the grains of the stone, but rises by the force of the attraction which the grains of sand exert, causing the cavities which exist between each of the grains of sand of which the stone is composed to be filled, and as those cavities are small, in close contiguity and communication, the water is readily attracted into them.

The grains of sand which constitute the Red Sandstone, vary in size in the several strata of the rock. They are small and closely fitting in some strata, and coarse with larger cavities in others; consequently water will pass more freely through the coarse grain than the fine grain rock. There are also numerous cracks and fissures in the rocks which assist in collecting and facilitating the passage of water through their mass from a higher to a lower level. The altitude of the source of the water above the level at which it is taken from the rock, is also a very important element in the calculation of the quantity which may be obtained from any well, the position of which is given.

I found by experiment that one square foot of compact stone $10\frac{1}{2}$ inches in thickness and of average coarseness, passed the following quantities of water through per hour:—

At a pressure of 10 lbs. to the square inch, $4\frac{1}{4}$ gals.
At a „ „ 20 „ to the square inch, $7\frac{1}{2}$ „
At a „ „ 46 „ to the square inch, 19 „
The increase being nearly directly as the pressure.

I have also made an experiment with the view of ascertaining the quantity of water required to fill the cavities, or, in other words, to saturate, sandstone of an average degree of coarseness, and find that it will contain about $\frac{1}{22}$ of its own weight of water, and if it is allowed to drain, about $\frac{1}{10}$ of that quantity will run out by the influence of gravity; the remainder is held in the cavities of the stone by capillary attraction.

I shall now ask you to consider the reasonableness or otherwise of the hypothesis which fixes the source of the water supply in the sandstones of Liverpool in distant hills, and we shall receive considerable assistance in arriving at a proper conclusion in reference to this part of the inquiry by bearing in mind the principles of hydrostatic pressure. It will not be necessary for me to occupy much space in proving the incorrectness of the hypothesis here referred to. We have only to look around and examine the nature and levels of the ground and sea which are contiguous to Liverpool, to be convinced that it is impossible for water to cross the River Mersey from the Cheshire side unmixed with sea water, and it is not probable that water from places which lie beyond Aintree, Litherland, Chatmoss, and other like lowlands, could flow to Liverpool.

The Triassic Sandstones do not extend continuously as far as Wales or Cumberland, and if they did so continue, the water could not overcome the friction caused by many miles of rock.

From whence does the water come into the sandstones of Liverpool? The answer is twofold—First, the

rain which still falls upon the few—very few—uncovered patches of rock, or pervious sand which overlies the rock—is conveyed through the strata (in the manner already described) to the lower levels to which it can flow to be at rest, whether such levels be in the wells, or in the River Mersey. If the wells happen to be the nearest receptacles, the water will flow into them; but if not, after rising in the rock so as to have sufficient elevation to overcome the capillary attraction and friction, it will flow into the River Mersey. Forty years ago, when Liverpool was about one third its present size—when the consumption of water was not a tithe of the present consumption—when large pervious surfaces were exposed to the sky—the inhabitants obtained rain water, slightly altered in composition, abundantly from the sandstones, and the surplus of the rain absorbed by the rock passed through the cavities and fissures into the River Mersey. But, as the population increased, as they built their houses and warehouses, and covered the surface of the ground with those and with impervious pavements, at the same time vastly increasing the consumption of water in various ways, a period was reached when the available rainfall was insufficient to meet the demand. Then the wells, which up to that period had yielded an abundant supply of good water, became dry, and had to be deepened. This operation was repeated time after time, all over Liverpool, until the wells were sunk to a depth of 40 to 60 feet below high-water mark of the tide in the river. By continuing the pumping from the wells, the rain water which had been stored in the cavities of the rock was abstracted to a considerable depth below the level of the sea. Then came the reaction. The rain water, which had flowed for ages through the rock into the river, gave place to a

current passing in the opposite direction, that is, from the river into the rock, to restore the equilibrium which the pumping from the wells had disturbed. The consequence was, those wells which were nearest the river, and were pumped the hardest, yielded brackish water; gradually, as the demands of the wells increased, the current through the sandstone from the river became stronger, and extended further inland, and the wells near the River Mersey yielded water more brackish than before.

The current from the river at last reached the middle of the town—weak at its head, but gaining strength behind. It flowed eastward, northward and southward, and it is still flowing in those directions. In due time it will reach the public wells at Bootle, Green-lane, and Dudlow-lane, and they will have to be abandoned, as their prototypes in Bevington Bush, Soho-street, Hotham-street, and other places have been. The time for the fulfilment of this prediction may not be very near—a few years may elapse; but come it must, although it will be delayed longer if the present mode of mixing the Rivington and the well waters is continued. The Rivington water being almost free from salts in solution, will dilute the increasing quantity of salts in the well waters, and so will render these waters useful for a longer period than would be the case if the waters respectively were supplied unmixed.

I shall now briefly describe seven wells, five of which I have either sunk or deepened during the last eight years. The first is situate in Earl-street, at a distance of about 350 yards from the River Mersey. It is sunk in the Red Sandstone to the depth of 32 feet below high-water mark, and is perceptibly affected by the tide; for at high-water a rise in the well takes place, although the pumping is

continuous, but at low-water the water sinks in the well to nearly low-water mark.

The next well is situate in Rainford-square, at a distance of about 500 yards from the river. It is sunk in the Red Sandstone, and is relatively to the river one of the deepest wells in Liverpool, being 76 feet below high-water mark. The supply of water is abundant, but it is only fit for condensing purposes, owing to the large quantities of salts it holds in solution. The following analysis of the water was made for me by Mr. Edward Davis, F.C.S. :—

Mineral matter per gallon..................	231.00	grs.
Organic matter per „	1.75	„
	232.75	

The Mineral matter consists of

Chloride of Calcium.	Sulphate of Magnesium.
Chloride of Magnesium.	Carbonate of Lime.
Chloride of Potassium.	Carbonate of Magnesia.
Chloride of Sodium.	Oxide of Iron.
Sulphate of Lime.	Nitrate of Ammonia, a trace.

A few years ago the water in this well was suitable for generating steam, but it is now unfit for that purpose.

The next well is situate in Johnson-street, about 850 yards from the river. It is sunk in the Red Sandstone to a depth of 56 feet below high-water mark. The water in this well was analysed in January, 1850, by Mr. R. Phillips, of London, and found to contain the following salts per gallon :—

Sulphate of Lime........................	8·80	grains.
Carbonate of Lime	24·33	„
Chloride of Calcium....................	5·05	„

Chloride of Magnesium	20·80	grains.
Chloride of Sodium	55·79	„
	114·77	
Excess	37	
	114·40	grains.

The water up to that time, although impure, was suitable for brewing, but sometime after the above date it became so brackish that it could only be used for refrigerating purposes.

The next well is situate in Wellington-street, about 1,200 yards from the river. It is sunk to a depth of 71 feet below high-water mark, in the Keuper Sandstone. I have not obtained an analysis of the water in this well; but by the kindness of Mr. Westworth I am able to give the following analysis of the water in a well situate about 100 yards from the one in question, and sunk in the same formation. It will indicate approximately the quality of the water in the well referred to. The analysis was made on the 30th October, 1865, by Messrs. Huson and Audle, and is as follows:—The quantity of solid matter in one gallon is 117·70 grains, and consists of—

Sulphate of Lime	29·50	grains.
Chloride of Calcium	4·00	„
Chloride of Magnesium	33·60	„
Chloride of Sodium	47·60	„
Carbonate of Lime	2·00	„
Iron, alumina, water, and a trace of Nitrate of Soda	1·00	„
	117·70	grains.

Until recently the water from the well in Wellington-street was used for generating steam, but is now totally

unfit for that purpose, owing to the large amount of incrustation that soon deposits from it in the boilers. It is now only used for cleansing and refrigerating purposes.

The next well is situate at Bootle, about 1,800 yards from the river, and is the property of the Corporation of Liverpool. It is sunk in the Red Sandstone to a depth (as I am informed) of about 65 feet below high water mark, and considerable sums of money are now being spent in deepening and enlarging the lodges, and erecting new pumping engines, so as to obtain a larger supply of water. In the year 1850, Mr. Phillips analysed the water in this well, and it was found to contain 24 grains of solid matter in a gallon, consisting of the following:—

Sulphate of Lime	3·31	grains.
Carbonate of Lime	7·10	„
Carbonate of Magnesia	6·93	„
Chloride of Sodium	3·37	„
Silica	0·48	„
Organic matter, traces of Potassium and loss......................	2·81	„
	24·00	grains.

The next well is situate at Flaybrick Hill, in Cheshire, about 3,400 yards from the docks or river, and was sunk by me in the year 1862, to a depth of about 55 feet below high water mark. It is sunk in the Keuper Sandstone, and for a depth of 140 feet from the surface it was almost free from water; but when we had sunk it to within about ten feet of the level of high-water mark, water began to *weep* into the well through the cavities of the sandstone. There were no large fissures nor noticeable veins of clay in the strata, except near the surface, where there is a seam of clay shale about two feet in thickness. The *beds* and *backs*

of the strata fitted closely against each other, so that the water did not flow into the well at *intervals*, or at certain *points*, but exuded into it from the rock at every *pore*, like perspiration issuing from the pores of the skin. The quantity of water regularly increased with the depth of the well, and at 55 feet below high water mark the yield was about 350,000 gallons in 24 hours. This quantity was further increased by a borehole and adit which were afterwards made, to about 1,600,000 gallons in 24 hours.

What I have stated in reference to the closeness of the strata and the absence of large channels in the Flaybrick well, applies to all the wells I have sunk in the Keuper and Bunter formations; and I confidently state that there are no grounds for the theory still entertained by many persons, of large underground channels existing to convey water from a great distance into any of the wells sunk in the Trias Sandstones of these districts. The conditions of supply are these: Given the water in contact with the rock, and it will flow in any direction through it, into any receptacle, such as a well, made to receive it. If a plentiful supply of *fresh* water, as from a lake, river, or rainfall, exists nearer than the River Mersey to such well or receptacle, then the water collected will be *fresh* or nearly free from saline matter; but if such supply does not exist, if the River Mersey is the nearest source, then the latter will afford to this porous sandstone a supply as inexhaustible as the sea, and in the course of time, if the pumping be continued, nearly as saline also.

The last well I shall refer to is at Green-lane. It is sunk in the Red Sandstone to a depth of 68 feet below high-water mark, and is now being enlarged so as to increase the yield of water. In the year 1850 Mr. Phillips made

the following analysis of the water. One gallon contained—

Carbonate of Lime...	5.26	grains.
Chloride of Sodium	2.66	„
Sulphate of Soda	2.23	„
Silica	0.64	„
Organic matter and loss	2.81	„
	13.60	grains.

I shall now ask your attention to the composition of a sample of water taken by me, on the 16th day of February last, from the River Mersey. It was taken at half-tide ebb, off the South Landing Stage, and analysed for me by Mr. A. Norman Tate, F.C.S.

The quantity of solid matter equals 1558·08 grains to the gallon, and consists of the following ingredients:—

Carbonate of Lime	0·64	grains.
Carbonate of Magnesia	0·80	„
Sulphate of Lime..............	56·44	„
Sulphate of Magnesia	113·14	„
Chloride of Magnesium	85·60	„
Chloride of Potassium..........	5·32	„
Chloride of Sodium	1295·50	„
Silica	0·64	„
Alkaline Nitrates—trace.		
Iodides and Bromides—trace.		
Organic matter—not determined.		
	1558·08	„

In juxtaposition to this analysis, I quote the following of water taken from a well in Great Howard-street, situate within 200 yards of the docks. The analysis was made by

Mr. Phillips, of London, in the year 1850. One gallon of the water yielded—

Sulphate of Lime	144·00	grains.
Carbonate of Lime	28·70	„
Chloride of Magnesia	209·00	„
Chloride of Sodium	531·00	„
Silica	0·32	„
Organic matter, traces of Potassium, Peroxide of Iron, and loss	1·30	„
	914·32	„

It would be instructive to men of science, and also advantageous to the consumers of water in Liverpool and Birkenhead, if the water in the wells at Bootle, Green-lane, Dudlow-lane, and Flaybrick Hill were analysed yearly. In this way the progressional deterioration of the water would be noted, and timely measures could be taken to secure a new source of supply before the increasing salinity of the water had rendered it unfit for domestic use.

The quantity of water supplied by the Corporation in Liverpool at the present time seems to be about 13,300,000 gallons a day. Of this quantity about five million gallons are supplied from the wells, and when the new adits, bore-holes, and pumping engines which are now in course of construction are completed, the supply will be considerably increased. There are also in Liverpool a great number of private wells, drawing water from the sandstones; and if I were to hazard a guess, I should say they collectively yield six million gallons of water a day. Add these figures together, and probably 10 to 12 million gallons of water a day are drawn from the sandstones in and close to Liverpool, being a quantity much larger than

the rainfall which can possibly penetrate to the rock from a surface that is now so extensively covered by houses, paved streets, sewers and boulder clay.

The consequences that will follow may easily be predicted. The porous sandstones will receive a supply of water and pass it to the wells in quantities equal to any that are likely to be drawn from them; for when we consider the great area of our docks, the bottoms of which are sunk into the sandstones, and also consider the large surfaces of sandstones which crop up on the shores and under the bed of the River Mersey, we need not fear the supply will fail us till the sea is dry or has changed its level; but we shall have the water gradually becoming more highly charged with saline matters, until ultimately it becomes unfit for domestic use.

In conclusion, I submit that the following inferences are fairly deducible from a full consideration of the several facts which I have cited:—That salt water permeates extensively through the sandstones in Liverpool. That the sandstones are capable of filtering, absorbing, or neutralising large quantities of the salts which are held in solution by sea water; the quantity so absorbed depending upon the extent of the sandstone through which the water permeates. That in two or more wells, which are sunk in similar strata, to the same depth below the level of the sea, and equidistant from it, that well will soonest yield saline water which is pumped the hardest, or made to yield the largest quantity of water in a given time. This, to a great extent, explains the differences in the several analyses given above. That when saline water enters any well, and the quantity pumped from it is steadily maintained or increased, the strength of such saline water, or the quantity of salts which are held in solution by it, will continue to increase, until

ultimately the water in the well will approach the salinity of the sea.

Other inferences will present themselves to the minds of those who have followed and understood the facts which I have given in the foregoing paper.

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THE

GEOLOGY AND MINERAL VEINS

OF THE

Country around Shelve,

SHROPSHIRE,

WITH A NOTICE OF THE BREIDDEN HILLS.

BY

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THE GEOLOGY

OF THE

COUNTRY AROUND SHELVE.

BY G. H. MORTON, F.G.S., F.R.G.S.I.

INTRODUCTION.

SHELVE is a remote parish situated in the western part of Shropshire, and is in the centre of a remarkable tract of country, where the Llandeilo, or Lower Silurian strata of Sir R. I. Murchison, are prominently developed.* The district forms a portion of the ancient kingdom of the Silures, who, under their chief, Caractacus, so strenuously opposed the settlement of the Romans in England and Wales, and whose name has been perpetuated by that eminent geologist. In the *Silurian System*, and in the more recent work, *Siluria*, the geology of the country is described; and in the *Intellectual Observer* the two following papers will be found, viz.:—"Roman Mining Operations on the Borders of Wales," by Thomas Wright, M.A., F.S.A.,

* "Shelve: simple and in composition. *Ir. Scealp*, a cliff. Gael. *Sgealb, fragmentum lapidis*. Shelve, under the Stiperstones."—*Salopia Antiqua*.

Vol. i, for May, 1862; and "A Ramble in West Shropshire," by the Rev. J. D. La Touche, Vol. vi, for June, 1867.

The country around Shelve, within a radius of five miles, is of great geological interest, for it is not only a part of the typical Silurian region, but the strata in many localities are extremely fossiliferous. The centre of the district is bleak and uncultivated, varying in elevation from 500 to 1,660 feet above the level of the sea, and is very thinly inhabited by a mining population.

There are many prominent hills, though the Corndon is the most conspicuous, for it is isolated, and reaches an elevation of 1,660 feet above the sea, or 700 feet above the Gravels. It is, however, a more commanding object when viewed from the neighbourhood of Montgomery, where the country is only about 500 feet above the sea level. Another hill, Bromlow Callow, is about 1,200 feet above the sea, and can be seen for miles over the surrounding country, as it is crowned by a clump of fir trees. Stapeley Hill is 1,300 feet, Shelve Hill 1,250 feet, Stiperstones 1,600 feet, and the Longmynd 1,400 to 1,600 feet above the level of the sea. All around the central hilly tract the land is cultivated, and presents a strong contrast to the bare and rugged country above it. The usual and most convenient way of access is from the railway station at Minsterley, which is just five miles from the Gravels, where the only inn in the district is situated. The road ascends along the side of a stream, a tributary of the Rea, through a defile whose sides, a few years ago, were clothed with forest trees, but which have been recently cut down, and the gorge shorn of its impressive grandeur.

From the summit of the Corndon a magnificent view of the surrounding country is obtained: to the east, the

Stiperstones, with their frequent rocky prominences, form a series of remarkable projections, while to the west, the beautiful vale of the Severn presents a long panoramic display of a highly cultivated country, bounded on each side by hills. Near the Corndon the surface includes bare rocks, rounded knolls, steep ravines, precipices, lakes, bogs, enclosed fields, and a variety of outline rarely to be seen within such a confined area.

Before proceeding to describe the geology of the country, it is desirable to refer to the historical associations connected with it. North of Stapeley Hill there is a circle of stones known as the CIRCLE, and as HOAR STONES. It is composed of thirty stones, but seems to have originally contained thirty-six to complete the ring. There is an upright one in the middle of the circle, and it is three feet high. Most of the stones project very little above the surface of the ground, while the others—three or four—are nearly as high as the central one, and the diameter of the circle is twenty-five yards. On the south of the same hill there is another well-known circle called MITCHELLS' FOLD. It contains fifteen stones, one being six feet high; and it seems probable, judging from the distances between those that are near together, that thirty-six may have been the original number; but there is no central stone. The diameter is thirty yards. About one hundred yards to the southeast there is another circle, which is only fifteen yards across, but the stones are all broken off near the surface; and some distance to the N.E. there is a smaller circle. A group of stones, named "WHETSTONES" on the ordnance map, was removed some ten years ago. They seemed to have been used in some polishing or sharpening process; hence, perhaps, their name. The origin of these several monuments is, of course, unknown, though they seem to be

Druidical, and, perhaps, the sites of ancient burial places. They are described in *Salopia Antiqua*.

In the parish of Chirbury, a few miles to the west of Shelve, barrows and traces of ancient encampments occur, while the line of the retreat of Caractacus and his brave British forces, before the advancing Roman General Ostorius, is indicated by numerous defensive vestiges over the neighbouring eminences, and by a Roman work, CAER FLÔS, N.W. of Montgomery. A mile E.N.E. from Shelve church there are two tumuli. Remains of a Roman villa have been discovered near Pontesbury, and another close to Linley Hall, where a portion of a Hypocaust is still uncovered, and fragments of red tiles of the same age lie scattered about. There are conclusive proofs that the Romans worked the mineral veins for which Shelve is celebrated, and that they were at the same time peaceably settled in some of the surrounding valleys.

The Forest of the Stiperstones, of which this district formed a part, was a chase of the Saxon kings. In the year 1190, Richard the First granted a charter conveying the "Forest of Tenefrestanes" to the Baron of Caus, and there are so many references to the lead obtained in the neighbourhood, as to prove that the mineral veins were extensively worked in the twelfth and thirteenth centuries. In *Eyton's Antiquities of Shropshire* "cart-loads of lead" are spoken of, but whether lead ore or pure lead is not stated, though it is certain that the smelting operation was performed near the mines. There can be little doubt that the mines gave some importance to Shelve and the neighbouring parish of Hope at that time, and so led to a lawsuit in 1292, in which the extent of the Stiperstones Forest was the subject of dispute. There seems to have been a church at Shelve in the fourteenth century, but the

present structure is a rude modern edifice. Near the church there are a few farm buildings; but there was once a village, where a market was held, though there is nothing of the kind now. The church and Rector's house at Hope are, however, superior erections, and with the taste displayed in the arrangement of the grounds about them, present an agreeable contrast to the primitive dwellings of the mining population.

In a district of such varying contour, the drainage lines naturally present some interesting features. On the turnpike road about half a mile S.W. from the Gravels, there is a remarkable watershed, where two rivulets run from a very limited area, in opposite directions; one of them, having its source on Shelve Hill and the Marsh Pool, passes along Hessington Marsh, and through a narrow defile in the Stiperstones in Linley Park, after which it joins the Onny and the Teme, tributaries of the Severn; the other rivulet originates from the drainage of the land north of Stapeley Hill, descends by the Gravels, Hope, and Minsterley into the Rea, another branch of the Severn, which enters it at Shrewsbury.

The contour of the country seems to be entirely the result of subaërial denudation, acting on rocks of unequal hardness, from a remote geological antiquity. Probably the waves of ancient seas, and ice, may have modified its configuration, although the appearance now presented by the entire surface is exactly such as might be expected to result from the long-continued action of atmospheric phenomena. The central mass of the Corndon is composed of greenstone. It is an eruptive rock; and there are several other masses of the same greenstone around the flanks of the Corndon, all conspicuous by their hard and rugged outlines. Stapeley Hill is formed of beds of

felspathic ash and dykes of greenstone; the Stiperstones of quartzite; and Shelve Hill of Llandeilo shale; but along that hill for a mile, both to the north and south of the church, a greenstone dyke projects at frequent intervals above the surface, or covers the ground with fragments of the rock. The strata of which the country is chiefly composed are shales and fine sandstones, of various degrees of hardness, but usually more friable than the felspathic ash-beds and quartzites interstratified with them, or the greenstone that has burst through them; consequently the valleys are hollowed out of the softest strata, while the ridges and hills are principally formed of hard eruptive and other rocks of igneous origin. The present rivulets and streams seem to be very inadequate to cause any great change in the valleys along which they flow, but on the sides of the steeper hills, where they originate, their power of cutting into the strata, and the gradual formation of deep ravines can be seen and studied under every possible aspect.

The country around Shelve is usually covered by drift, and though the rock is generally at a very slight depth beneath, it is often exposed at the surface. The most remarkable scenery in the district is the ridge of the Stiperstones, presenting a succession of projecting crags which stand out in towering grandeur along its crest. The most conspicuous is known as the Devil's Chair, a mass of ruinous rocks, sixty feet high and one hundred and twenty feet broad; broken, fissured, and surrounded by vast heaps of stone, it resembles in its loftiness some ancient ruin, with an ever-changing character as the varying light from sunrise to sunset falls upon it from various points.

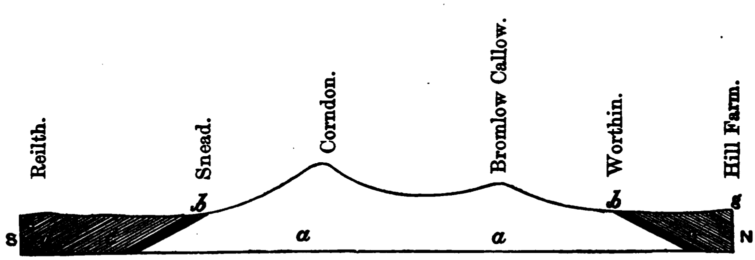
No decided indication of the former presence or passage of ice over the land has been observed about Shelve, but as

many places likely to be striated by glacial action are covered by drift, there may be such surfaces undiscovered. The drift is a mixture of clay and sand. It contains numerous boulders and small stones; many are angular, some of them ice-scratched, and they are of local origin, including greenstone, felspathic ash, quartzite, sandstone, and slaty rock. There are, however, few large boulders, and the deposit seems to be uniform in character, perhaps merely representing the waste of the land modified by icy action of a glacial character. No shells have been noticed in this drift.

Stratified Rocks and Fossils.

The stratified rocks around Shelve principally belong to the Llandeilo formation, or Lower Silurian of Sir R. I. Murchison. They are in part surrounded by a fringe of Upper Llandovery and Wenlock deposits which repose unconformably upon them. On the east the Llandeilo and Lingula Flags rest on the Cambrian strata of the Longmynds. A line of section from the Corndon, either to the north or the south, presents an ascending order of Silurian rocks; and by uniting the two sections the following remarkable arrangement is exhibited, with the Llandeilo formation in the centre:—

Section from the Corndon, North and South.



a Llandeilo Formation. *b* Upper Llandovery Limestone. *c* Wenlock Shale. *d* Ludlow Rock. *g* Old Red Sandstone.

Taking cognizance of this extended line of country, no less than five geological formations occur within the length of fifteen miles, and the succession is shown by the order in which they succeed each other to the north and south, from the Corndon. In addition to the border of Upper Silurian, the Llandeilo area contains several small outliers of Upper Llandovery strata, at various distances from the boundary line, so that it is obvious that the Lower Silurian rocks were originally covered, and have been subsequently exposed by denudation. It seems probable that not only the Upper Llandovery, but also the Wenlock shale, the Ludlow series, and the Old Red Sandstone have been denuded.

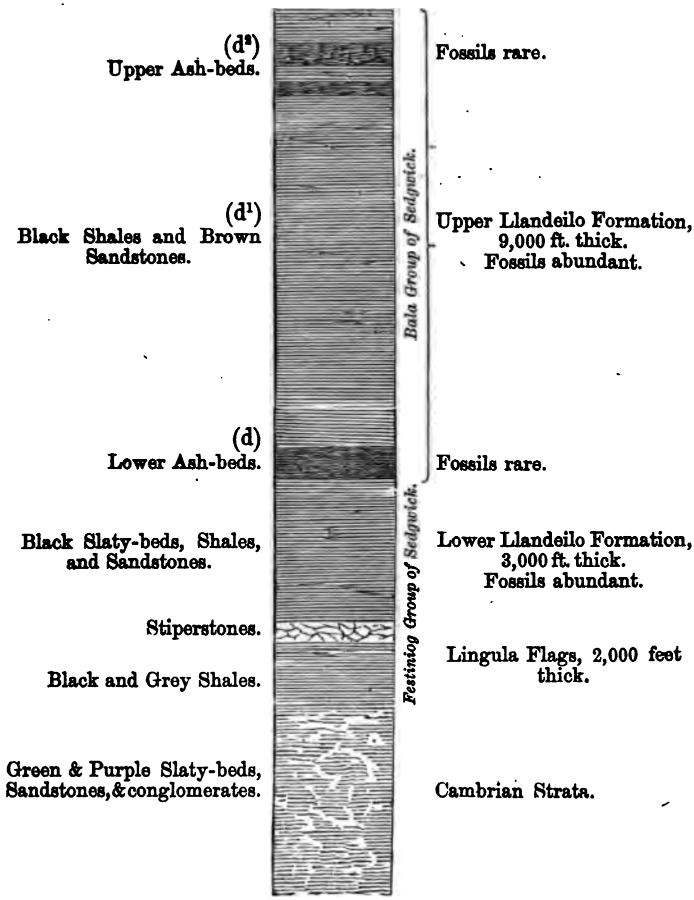
The summit of the Longmynd range is four miles to the S.E. of the Stiperstones. About a mile to the east of the latter the Cambrian strata are exposed in many places, and consist of purple and green shales, sandstones, and conglomerates. Alternations of these slaty rocks continue over the Longmynd as far as Church Stretton, which is seven miles from the Stiperstones. The thickness of this grand exposure of Cambrian strata has been determined to be 26,000 feet. The strata do not seem to contain fossils, excepting some Annelide tracks, *Arenicola didyma*, and a single specimen of what has been doubtfully considered to be the pygidium of a trilobite, *Palæopyge Ramsayi.* These specimens were obtained at Carding Mill, one mile from Church Stretton, and consequently near the base of the Cambrian series. Fine Annelide tracks have lately been obtained near Little Stretton, so that they may be considered of common occurrence. The Annelide tracks are associated with ripple-marks, rain-prints and sun-cracks, and specimens can be seen, including the trilobite tail, in the Museum of Practical Geology, Jermyn Street, London.

There are many greenstone dykes associated with the slaty rocks of the Longmynd, some of which are shown on the maps of the Geological Survey.

Lingula Flags.

Directly reposing on the Cambrian strata there is a series of black and grey shales and sandstones, which are succeeded in regular ascending order by the quartzite beds of the Stiperstones. From the character and position of these shales and sandstones, they have been coloured as Lingula Flags on the Survey maps; and although recent discoveries at Tremadoc, St. David's, and other places, have thrown additional light on the lower beds of the Silurian system since their publication, it does not seem that any better classification of these strata could be adopted, in the total absence of organic remains. These Lingula Flags are well exposed on the road S.E. of the Bog Mine, a quarter of a mile from the Stiperstones, but nothing decidedly organic has been found, although there are impressions somewhat resembling the tracks of Annelides. In the overlying quartzites—which are simply hardened sandstones—very distinct Annelide burrows, *Scolithus linearis;* and casts of seaweeds, *Crusiana,* have been found. The small flat cavities, said to contain fragments of *Lingula,* have not afforded the author a trace of any fossil whatever; but the flakes of anthracite described by Sir R. Murchison as occurring at Granham, near Pontesbury, were easily detected. These siliceous strata dip at an angle of 60° or 70° to W.N.W., and vary from flagstones to beds several feet thick. At the northern extremity of the Stiperstones the quartzite becomes in places a conglomerate.

Vertical Section.

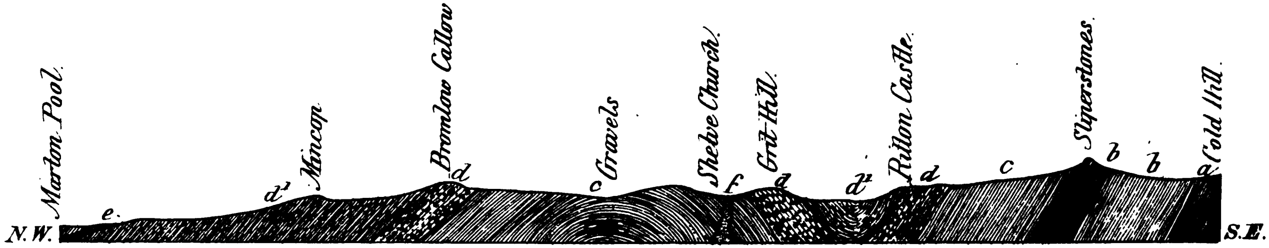


This section exhibits the thickness and subdivisions of the Llandeilo formation, as developed in the country around Shelve. The Lingula Flags form the base, while the upper limit is not defined, for it probably passes gradually into the overlying Caradoc or Bala formation, with which it is intimately connected. The thickness of the Llandeilo strata—14,000 feet—has been calculated principally from

PLATE. I.

SECTION FROM THE STIPERSTONES TO MARTON POOL.

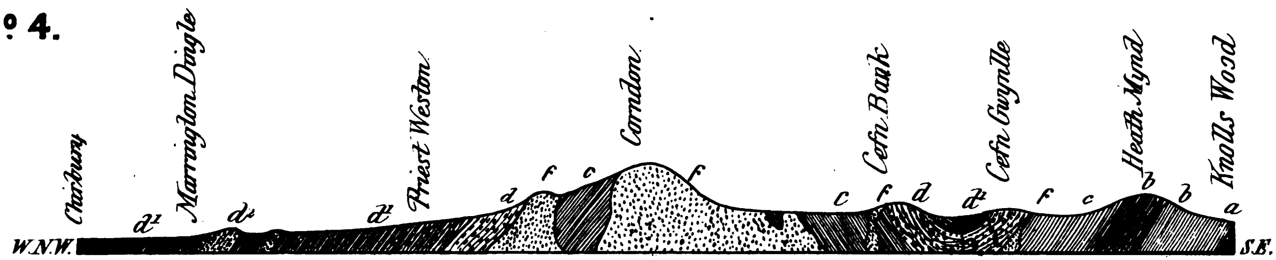
No. 3



a. Cambrian. b. Lingula Flags c. Lower Llandeilo d. Upper Llandeilo.
e. Llandovery Limestone f. Greenstone

SECTION FROM HEATH MYND TO CHIRBURY.

No. 4.



a. Cambrian   b. Lingula Flags   c. Lower Llandeilo   d. Upper Llandeilo

f Greenstone.

the maps and horizontal sections of the Geological Survey (Maps No. 60 N.E., and 60 S.E., Sections No. 33 and 34), and a reference to them is necessary in order clearly to understand the details regarding the stratification of the district. The above section shows that the Llandeilo formation consists of an upper and a lower series, the separation being the result of lithological distinctions, confirmed by remarkable palæontological results. The section (Plate 1, No. 3) across Shelve Hill from the Stiperstones to Marton Pool, on the same line as the Survey section (No. 34), exhibits both the Upper and Lower Llandeilo rocks, with the Cambrian strata cropping out from beneath at the eastern end. The other section (No. 4), from the Heath Mynd to Chirbury, presents a similar succession a few miles to the south, where the strata have been deranged by a great protrusion of greenstone.

Lower Llandeilo Series.

The lowest beds of the Llandeilo formation rest on the quartzites of the Stiperstones, with the same inclination, and they can be examined at the head of Mytton Dingle and Perkins' Beech, where fossils may be obtained by a careful search, particularly in a sheephole at the top of the former ravine, where the rock is weathered to a reddish colour. It much resembles that brought up from the workings in the East Grit Mine, and the fossils being of the same species, it is inferred that strata belonging to the same horizon occur at both places. Besides, from the structure of the country, as shown in the sections (Plate 1), it is clear that a fold of the strata brings the beds immediately over the Stiperstones, near to the surface under Shelve Hill. In the mining debris about the head of Perkins' Beech, *Orthis calligramma* and *O. alata* are common, and the locality where these ravines originate is also fossiliferous.

The strata of the Lower Llandeilo series are of very uniform character, consisting of fine-grained shales, varying considerably in hardness, but never presenting any indication of slaty cleavage. The fracture of the rock when first brought up from the mines is of a massive slaty character; but after it has been exposed to the action of the atmosphere it splits along the line of bedding, and assumes the appearance of shale. The rock at the surface is principally shale of a soft, splintery character, but in the neighbourhood of the numerous greenstone dykes it is often a hard slaty rock—as at the highest part of Shelve Hill. The strata are usually nearly black, though there are light coloured shales; and there are beds of fine-grained, dark grey sandstone at the head of Perkins' Beech, and at the White Grit Mine. Occasionally there are thick flagstones interstratified with the shales, as at Hope church, where an instructive example of contorted strata occurs.

The following is a complete list of the fossils that have been found in the Lower Llandeilo series of Shelve—Arenig of Sedgwick—with the localities. The thickness of the series is 3,000 feet, and the relation of the Lower to the Upper Llandeilo strata is shown in the sections.

List of Lower Llandeilo (Arenig) Fossils.

**Orthoceras Avelinii*, Salt.	Cefn Gwynlle.
† ,, *encrinale*, Salt.	,,
* ,, *sp.*	,,
†*Bellerophon hippopus*, Salt.	Ritton Castle.
* ,, *carinarioides*, *n. sp.*	White Grit Mine.
* ,, *perturbatus*, Sow.	Shelve Church.
**Raphistoma*, *sp.*	White Grit Mine.
**Theca simplex*, Salt.	,,
* ,, *sp.*	Cefn Gwynlle.

* Found by the Author. † In the Museum of Practical Geology.

**Cucullella Anglica*, Salt.	Mytton Dingle and Grit Mine.
**Ribieria complanata*, Salt.	Grit Mine.
**Modiolopsis trapeziformis*, *n. sp.*	Spring Vein and Grit Mines.
**Palæarca amygdalis*, Salt.	White Grit Mine.
**Orthis calligramma*, Dalm.	Mytton Dingle and Perkins' Beech.
* " *alata*, Sow.	"
**Lingula attenuata*, Sow.	Grit & White Grit Mines.
**Obolella plumbea*, Salt.	"
**Discina, sp.*	Ritton Castle & Cefn Gwynlle.
†*Didymograpsus hirundo*, Salt.	Bog Mine.
* " *geminus*, His.	White Grit and Cefn Gwynlle.
**Graptolithus, sp.*	White Grit Mine.
**Dictyonema sociale*, Salt.	Ladywell Mine and Shelve Church.
**Æglina binodosa*, Salt.	Cefn Gwynlle.
†*Agnostus morea*, Salt.	"
**Calymene parvifrons*, Salt.	Mytton Dingle and Grit Mine.
†*Cheirurus pectinatus*, Salt.	Cefn Gwynlle.
†*Illænus perovalis*, Murch.	Bog Mine.
† " *large sp.*	"
**Ogygia Selwynii*, Salt.	Grit and other Mines.
**Trinucleus Murchisonii*, Salt.	White Grit and Cefn Gwynlle.

Upper Llandeilo Series.

The Upper Llandeilo strata are of a more varied lithological character than those of the lower part of the formation. The base of the series consists of slaty and sandy shales, interstratified with grits and felspathic ash. The ash-beds contain crystals of felspar, and there are strata

* Found by the Author. † In the Museum of Practical Geology.

of porcellanic rock of various shades of grey and blue, and others forming a regular breccia, all of which are probably of volcanic origin. Grit Hill, S.E. of Shelve Church, and Stapeley Hill are composed of these lower ash-beds, and the strata can be examined at both places, especially the latter. These strata seldom afford traces of fossils, and the only species recorded are *Cyclonema crebristria,** *Lingulæ*, and *Didymograpsus Murchisonii*,† from the Corndon Grits, on the authority of the Geological Survey. The lower ash-beds (see Pl. 1, Sec. 3 and 4 d,) form a synclinal axis between the Stiperstones and Shelve Hill, from which they have been denuded, though they come in again along the crest of Stapeley Hill, where they are well exposed, and dip to the west at an angle of 50°, with a strike of several miles from Leigh Hall to Hurdley. Much of the road stone employed along the Minsterley and Bishop's Castle road is obtained from the lower ash-beds that cross it on the east of the Corndon, and many beds have such a regular porphyritic structure, that a hand specimen would often be considered to be a felspathic porphyry. The same character is also observable in the anciently denuded boss of ash, which forms the floor of Hope Quarry, on the Minsterley road.

The lower ash-beds and associated strata are succeeded by dark shales, and then by thick strata of a peculiar brownish green sandstone, sufficiently hard to be used for mending the roads. This sandstone is quarried at Priest Weston, a village one mile west of the Corndon, and *Bellerophon bilobatus*, *Ogygia Corndensis*, a species of *Modiolopsis*, and two of *Ctenodonta* have been found. The Priest Weston sandstone dips 60° to the west, and the strike extends about two miles, both to the north and south.

* Catalogue of Fossils, Museum of Practical Geology. † Section No. 34.

In ascending order it is succeeded by the strata of Mincop and Meadow Town, composed of hard light grey sandstones, interstratified with shales possessing an indurated appearance. These sandstones, which run in beds about six inches thick, contain very good examples of *Strophomena compressa*, *Orthis testudinaria*, *Beyrichia complicata*, *Trinucleus concentricus*, *Calymene brevicapitata*, *Diplograpsus pristis*, *Pyritonema fasciculus*, *Glyptocrinus basalis*, and others. The shales associated with the sandstones in many places contain innumerable trilobite impressions, *Asaphus tyrannus*. About half a mile S.W. of Meadow Town, on the road to Rorrington, the rock is exposed, and *Ogygia Buchii* and *Lingula attenuata* occur in abundance. Near to the school at Middleton there is another similar locality which has been long known. In both of these places the strata are black and brown shales, and they are probably just over the light sandstones and associated shales, which may be appropriately called the Mincop series. The average dip of the strata is about 45° in a westerly direction.

The succeeding strata forming the highest part of the Llandeilo formation are principally shales of a dark colour. Near the top of the series the upper ash-beds (d^2) occur in two distinct bands, the higher one being fully exposed in the Whittery quarries, which are situated in the picturesque Marrington Dingle, where building stone is obtained in large quantities. The strata of ash are from six inches to twelve feet in thickness, and they are interstratified with beds of shale, the whole dipping to the west at an angle of 45°. In many instances fragments and thin seams of shale occur embedded in the ash, and such examples may be collected in hand specimens. In some of these shales parts of *Ogygia Buchii* have been detected, showing that the sea bottom was inhabited during the

deposition of the ashes, which are the result of submarine volcanic eruptions during the early Silurian period. The upper ash-beds are of a lighter colour than the lower ash-beds. The stone resembles a sandstone, and it is composed principally of granular felspar. A little west of the outcrop of the upper ash-beds the Llandeilo strata are overlapped by the Wenlock shale, but the country is flat and covered by drift after crossing Marrington Dingle. Fossils are rare in the uppermost beds, and most of the strata are soft shales which crumble under the action of the weather into minute fragments. The following is a list of the fossils, with the localities:—

List of Upper Llandeilo Fossils.

**Bellerophon bilobatus*, Sow.	Priest Weston.
†*Cyclonema crebristria*, M'Coy.	Corndon Grits.
‡*Euomphalus Corndensis*, Sow.	Leigh Hall.
**Ctenodonta*, *sp.*	Priest Weston.
**Modiolopsis*, *sp.*	,,
**Orthis testudinaria*, Dalm.	Mincop.
* ,, *small sp.*	,,
**Strophomena compressa*, Sow.	,,
**Lingula granulata*, Phil.	Meadow Town.
* ,, *attenuata*, Sow.	Mincop & Middleton.
**Orbiculoidea Forbesii*, Dav.	Middleton.
†*Didymograpsus Murchisonii* Beck.	Corndon Grits.
**Diplograpsus pristis*, His.	Mincop.
**Pyritonema fasciculus*, M'Coy.	Mincop.
**Asaphus tyrannus*, Murch.	Mincop and Meadow Town.
**Beyrichia complicata*, Salt.	Mincop.

* Found by the Author. † In the Museum of Practical Geology.
‡ Siluria, 3 ed., pl. 7, fig. 5.

**Calymene brevicapitata*, Portl.	Mincop.
**Ogygia Corndensis*, Murch.	Priest Weston.
* ,, *Buchii*, Brongn.	Meadow Town and Middleton.
**Trinucleus concentricus (v. falus)* Eaton.	Mincop.
* ,, *Lloydii*, Murch.	Middleton.
**Glyptocrinus basalis*, M'Coy.	Mincop.
†*Cyathocrinus, sp.*	Marrington Dingle.

A comparison of the lists of the Upper and Lower Llandeilo fossils shows that there is scarcely a species common to both. The *Lingula attenuata* is the only one that is inserted in the two lists; and it is represented by two very different varieties, that from the Upper Llandeilo being much larger than the variety found in the lower strata of the formation, though Mr. T. Davidson, F.G.S., considers them to be all one species. He has figured specimens of this, and other brachiopods from Shelve that are in the author's collection, in the "Monograph of British Fossil Brachiopoda," published by the Palæontographical Society.

Upper Llandovery Series.

This group belongs to the Upper Silurian, and there is a considerable break between it and the underlying Llandeilo strata. The latter were thrown into a highly inclined position, and were denuded before the Upper Llandovery beds were deposited horizontally over their upturned edges. In the neighbourhood of Snead and Norbury, a few miles south of Shelve, the Upper Llandovery rocks occur. They also fringe the Llandeilo area on the north, and there are outliers near the Bog Mine, at Venus Bank, and near Hope Hall in a plantation above the turnpike road. Hope Quarry on the same road, near Minsterley, is worked

* Found by the Author. † In the Museum of Practical Geology.

in Upper Llandovery strata, and the section exhibits sandstones interstratified with limestones, faulted against the Wenlock shale. The Llandovery beds are there seen reposing upon the Llandeilo shales and an ash-bed resembling a felstone porphyry, the whole presenting a section of considerable interest. The limestone is full of *Pentamerus oblongus*, and also contains the other fossils inserted in the list as occurring at Hope.

An examination of the several sections of these beds, in various places in the district, leads to the conclusion that the sandstones form the base of the Upper Llandovery formation, that the limestones succeed, and the thickness of the whole does not exceed one hundred feet. Some geologists seem to have considered that the Bog Mine beds belong to the Woolhope series,* and to be higher in geological position than the limestones of Norbury and Hope, for several of the fossils found there are unknown as Upper Llandovery species elsewhere. But, as many of them are common to two or more localities, though the Bog Mine sandstones have afforded the greatest number, including some Wenlock forms, there seems little to support such a conclusion, especially considering the lithological similarity of the strata in each locality, and the relative position of the outliers. The species in the following list are all in the Museum of Practical Geology, according to the catalogue of that institution, and specimens of nearly all of them have been found by the author.

List of Upper Llandovery Fossils.

Orthoceras conicum, His.	Norbury & Bog Mine.
,, *sp.*	Bog Mine.
Lituites cornu-arietis, Sow.	,,

* Catalogue of Fossils, Museum of Practical Geology. The species from Bog Mine, Shelve, are classified as from Woolhope beds.

Bellerophon dilatatus, Sow.	Bog Mine.
„ *trilobatus*, Sow.	„
„ *sp.*	„
Pterotheca avirostris, Salt.	„
Euomphalus, *sp.*	„
Holopella cancellata, Sow.	Hope.
„ *sp.*	Bog Mine.
Murchisonia or Eunema, *sp.*	„
Pleurotomaria jugosa, Salt.	Norbury.
„ *sp.*	„ & Bog Mine.
Raphistoma lenticularis, Sow.	„
Turbo tritorquatus, M'Coy.	Bog Mine.
Ambonychia, *sp.*	„
Pterinea, *sp.*	„
Goniophora, *sp.*	„
Mytilus Mytilimeris, Conr.	„
Atrypa reticularis, Linn.	Hope.
„ *hemisphærica*, Sow.	Norbury.
Orthis biforata, Schl.	Bog Mine.
„ *calligramma*, Dalm.	Hope.
Leptæna scissa, Salt.	Norbury.
Pentamerus oblongus, Sow.	„ and Hope.
„ *lens*, Sow.	„ „
Strophomena arenacea, Salt.	„
„ *compressa*, Sow.	Hope.
„ *Pecten*, Linn.	Norbury.
Rhynchonella tripartita, Sow.	Hope.
„ *Wilsonia*, Sow.	Bog Mine.
Fenestella subantiqua, d'Orb.	„
Calymene Blumenbachii, Brong.	„
Encrinurus punctatus, Brünn.	Hope, Norbury, and Bog Mine.
Phacops Stokesii, Edw.	Bog Mine.
Cornulites serpularius, Schl.	„

Tentaculites Anglicus, Salt.	Bog Mine and Hope.
Syringopora serpens, Linn.	Norbury.
Cyathophyllum, *sp.*	Bog Mine.
Favosites alveolaris, Blainv.	„ and Hope.
Heliolites favosus, M'Coy.	Hope.
Omphyma, *sp.*	Bog Mine.
Petraia elongata, Phil.	Norbury.
„ *subduplicata*, M'Coy.	Bog Mine.
„ *bina*, Lons.	„

Most of the fossils in this and the foregoing lists will be found in Murchison's *Siluria*.

THE

MINERAL VEINS

OF

SHELVE.

By George H. Morton, F.G.S., F.R.G.S.I.

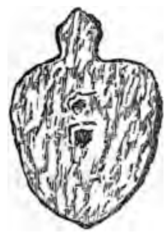
Shelve is a mining district. The land is poor and profitless on the surface, while the rocks beneath are rich in mineral wealth. The veins of lead have been worked at intervals since soon after the Romans landed in Britain, and they still yield large quantities of ore. When they were first discovered it is probable that the lead was exposed in ridges down the hill sides, for even now the siliceous contents of some of them can be traced along the surface; and between the Grit Mines the Ryder Vein forms a projecting wall for several yards. The very early occupation of this secluded part of England by the Romans shows that they attached considerable importance to its mineral wealth.

Evidences of ancient mining operations on a large scale are exposed on the western side of Shelve Hill, over the

present workings of the Roman Gravels Lead Mining Company. There are conclusive proofs that the Romans worked these veins or lodes at the Gravels, for not only have their coins, pottery,* and mining implements been found among the rubbish, but a Roman pig of lead was found some years ago at the bottom of the trench along the Roman Vein, with the curious wooden spades represented in the following woodcut:—

Oak Spades found in the Roman Mine at the Gravels.

16 inches by 8½.



11 inches by 8½.

Both the pig of lead and the spades, with other Roman relics, are preserved at Linley Hall, the seat of the Rev. T. F. More, who is the owner of Shelve Hill and other property in the neighbourhood, and whose residence is charmingly situated in "one of the most lovely spots in this island."

There are two other pigs of lead that have been found in the neighbourhood of Shelve; one, from Snailbeach, is in the British Museum, and the other, from Snead, in the Mayer collection at the Liverpool Museum, is shown in the following woodcut. They all bear the same inscription of the Emperor Hadrian (A.D. 117—138).

* Coins and pottery, on Mr. Wright's authority.

ROMAN PIG OF LEAD, FROM SNEAD.

FRONT 19¼ IN. LONG, 3½ IN. BROAD.

BASE 22 „ „ 7¼ „ „

THICKNESS, 4⅜ IN.

These pigs of lead prove that the mines were in operation early in the second century, when the Romans were peaceably settled in some of the secluded dales that descend from the higher ground. In the Roman trench two old candles were also found, the tallow having been changed into adipocere, and the wicks were made of hemp.

The ancient excavations at the Gravels are the only works of the kind in the district. They originally consisted of three artificial cuttings of a remarkable character. Following the course of the Sawpit, Roman, and Second North Veins, they extend as furrows up the side, and over the crest of the hill. Those over the two first-named veins are the most distinctly traceable, but the Roman is in every respect the most important excavation. In its present condition it presents a deep groove up the hill-side, and is continued over the top in the form of an irregular trench, ending in a series of holes, like shafts whose upper edges have fallen in, the whole being along the outcrop of the Roman Vein, in a southeasterly direction, for about two hundred yards. At the end of the main opening the lode have been followed underground, and the contents of the vein extracted. The depth of the open-workings is now from twenty to fifty feet, but as the bottom of them is obscured with debris the lower part cannot be seen. Not only is the width of the vein apparent where its contents has been abstracted, but its filling of carbonate of lime and slaty rock is conspicuous at the termination of the cutting. Where exposed the vein is from two to six feet wide; but lower down in the mine it varies from six inches to ten feet in width. The ancient miners worked out the vein to the depth of about one hundred feet, but not to so low a level as the bottom of the valley; and the surface of the ground along which the brook now runs is several feet higher than it was

formerly. The top of the shaft, on the hill, at the end of the Roman Vein, is two hundred and thirty feet above the Sawpit level at the bottom, and about fifty feet above the highest end of the ancient trench. Just under where the old miners abandoned their work a large quantity of lead was left; and as they did not exhaust the ore within their reach, or were stopped by water flooding them out, no reason can be assigned for the suspension of their operations. The form of the cutting along the Roman vein is very different now, compared with what it was before the present mine was opened. Fifty years ago its condition was that of a simple unbroken furrow along the outcrop of the vein, and it is currently reported in the district that some old levels with traces of shafts formerly existed; but there is nothing of the kind now. Its present excavated appearance is the result of mining operations which have since taken place below the surface. The vein was found to be very productive immediately below the bottom of the ancient trench, which was, however, almost filled with debris, and the extraction of this ore, some thirty or forty years ago, caused the contents of the old works to fall in at several points. The sides of the openings and some shafts that had been sunk have since fallen in, and the present rugged aspect of the whole produced. The result of this partial subsidence allows the parts of the veins that have not been worked to be seen from the surface, and a small excavation, into which a string of ore has been followed, is exposed in one of the fissures, while the general and irregular course of the lode is clearly discernible.

Roman mines, it is said, may be distinguished, apart from their superficial character, by the obvious avoidance of hard projections, which would now be cut away; but

probably the mining excavations made a thousand years later, present a similar contrast when compared with the skilful mode of working in the present day. Although the finding of the Roman pig of lead in the trench conclusively proves that the mine at the Gravels was worked by the Romans, it is very probable that their excavations may have been enlarged by more recent miners. It seems unlikely that the openings that they made should have remained untouched during the twelfth and thirteenth centuries, when lead was certainly obtained in abundance, and most likely at the Gravels, besides other places.

A comprehensive view of the ancient mining cuttings on Shelve Hill can be obtained from the opposite side of the valley, on the rising ground on the way to Callow Hill. The open Roman trench is there seen from a higher elevation, and its artificial character rendered very prominent. The excavations resemble quarry workings, and having rugged steep sides a fence has been set about the place. The cuttings or furrows over the Sawpit and Second North Veins are also visible from that place.

All the antiquities that have been found connected with the mines of Shelve seem to have been referred to the Roman period; and although it has been shown that they were worked in the twelfth and thirteenth centuries, it does not appear that anything has been found in the district throwing light on the working of any particular mine during that period; but that they were worked has been satisfactorily proved.

The discovery of lead slag in the neighbourhood of Shelve deserves attention; for, in the article published in the *Intellectual Observer*, referred to at page 1, its author says, "no traces of the washing and smelting places attached to these Roman mines have yet been met with,"

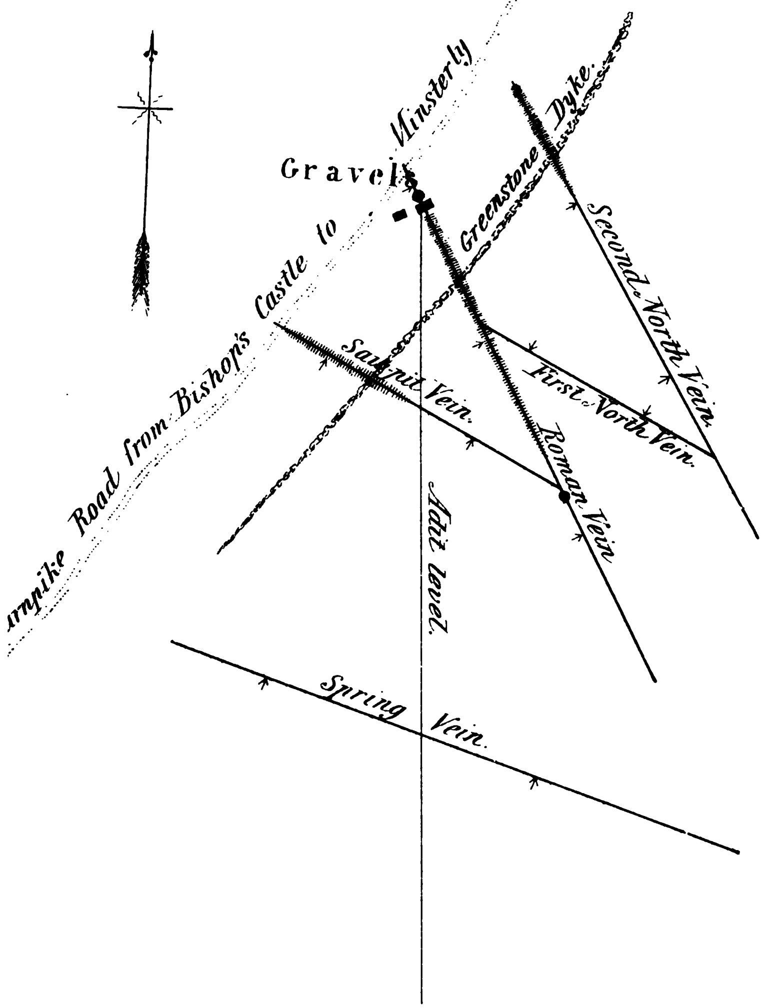
though the occurrence of slag is common in the neighbourhood, and is well known to the inhabitants. It is abundant on the flat ground on Shelve Hill, just over the north veins above the Gravels, and on the west side of the stream, a few hundred yards north of the inn. The Rev. Edward Tomlinson, M.A., Rector of Hope, informs me that slag occurs opposite the back of the "Tankerville Arms," but on the west side of the stream, and Captain Bennett states that he has observed it at the East Grit Mine. Most of this slag contains particles of lead, for it has been imperfectly smelted; and at the locality above the Gravels there are pieces of what seem to have been portions of the brick lining of the kilns or furnaces. At the present time there is not a vestige of any building at these places that can have had any connection with the smelting process; and possibly some of the slag dates from the Roman, and some from later, periods.

Gravels Veins.

At the Gravels there are five principal veins, viz., the Spring Vein, which is the most southern, then the Sawpit, Roman, First North, and Second North Veins. They are all within the space of 1,100 feet where furthest apart, though the Spring Vein is 600 feet to the south of the Sawpit Vein. The Roman Vein is the most valuable one: it has produced seven-eighths of all the lead ore raised from the mine, and is now yielding a large quantity, at the depth of 480 feet below the turnpike road. An adit level passes through the whole of these veins at 120 feet below the surface of the ground at the engine shaft, which is about 30 feet above the road, and 60 feet higher than the brook running in the valley below. None of the veins have been worked beyond the road, except for a few yards, for in that direction the strata change from hard slaty rock to soft shale,

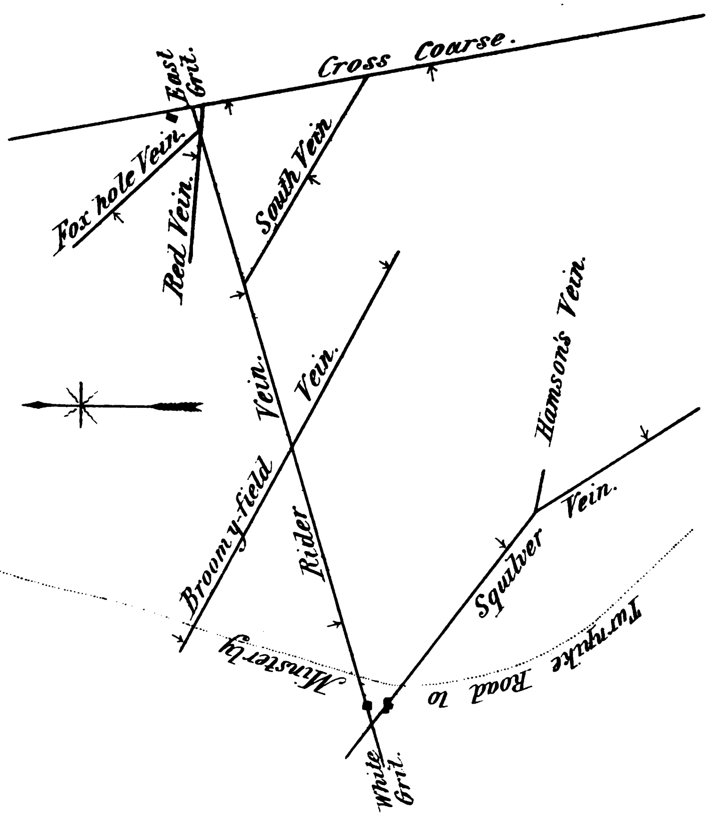
in which they are lost. The hard rock can be seen at the surface on the hill side, behind the engine-house, and it dips at an angle of 25° W.N.W. A greenstone dyke can be traced along the hill through the Roman Vein, in a northern direction, under the old buildings at Batholes Mine, until it terminates about a quarter of a mile from the Gravels. This greenstone seems to have hardened the strata through which it has been forced, and it is evidently the cause of the steepness of the hill at the Gravels, for the hardness of the rock has resisted the denudation that has caused the more gradual descent from Shelve Hill further to the north and south. The Roman Vein has been followed in a southeasterly direction, and was found to terminate in the same condition as at its other extremity. The following ground-plan of the outcrop of the Gravels Veins (Pl. 2) is reduced from one kindly drawn for the author by Capt. R. H. Vivian, who has also given all the information in his power regarding the working of the veins in early times. The relative position and inclination of each vein, the direction of the road, the adit level, and the greenstone dyke are all shown, while the lines across the Sawpit, Roman, and Second North Veins indicate the traces of ancient mining operations. A felspathic rock, forming a part of the greenstone dyke, has been observed at the bottom of the mine at the depth of six hundred feet, and it may continue more to the south, as shown on the plan. About a quarter of a mile to the east another and more important dyke of the same eruptive rock occurs, and there is a strong probability that a large mass of greenstone underlies Shelve Hill; and that it has not only hardened the strata around it, but has produced the anticlinal across the hill, with the numerous fissures, which have since become metalliferous veins, by the precipitation

GRAVELS VEINS.



SCALE 64 FATHOMS TO AN INCH.

PLATE 3.



WHITE GRIT & EAST GRIT VEINS.

SCALE 12 CHAINS TO AN INCH.

of Calcite, Galena, and Blende therein. The valley along the N.W. of the hill has been denuded in the soft shale, which seems to have been beyond the influence of the greenstone when it was forced upwards in a semi-fluid condition.

White Grit and East Grit Veins.

These veins were worked about two miles from the Gravels, near the southern extremity of Shelve Hill, at the White Grit and East Grit Mines, which are half a mile apart. They have both worked the Ryder Vein, which is one of the most important in the district. Nearly at a right angle with the Ryder is the Cross Course Vein, which seems to be a line of dislocation, cutting off the veins that strike against it. There are several other veins, all connected with the Ryder, including the Squilver, which bifurcates near its southeastern end. They hade or incline downwards in different directions, and at various angles, as indicated by arrows on the ground-plan (Pl. 3), which has been reduced one-half from a map provided for the purpose through the courtesy of Mr. Joseph Whittall, of Linley. Captain W. Bennett has also contributed the result of his long experience in connection with these mines.

In working the Ryder at the White Grit Mine, in a westerly direction, the vein was lost in passing from hard slaty rock into soft shale, but it appeared to continue under the latter. From the end of a level eighty yards below the surface a winze forty yards deep was then sunk, another level was advanced, and the lode worked, until the shale was again reached at the distance of forty yards, proving the dip to be forty-five degrees. The same operations were carried out three times, when it was decided to try the result of driving a level through the shale, in hope of finding some other vein. This was done, and after penetrating the soft rock about six hundred feet the undertaking

was given up, and the mine abandoned several years ago. The uniform inclination of the shale over the slaty rock is very clear from these mining operations at the White Grit, though it is probable that the difference in the nature of the rock is due to the greenstone having hardened the lower strata, which otherwise would have been a soft shale like the overlying beds. The White Grit Mine has been worked to the depth of 600 feet, and the East Grit 630 feet.

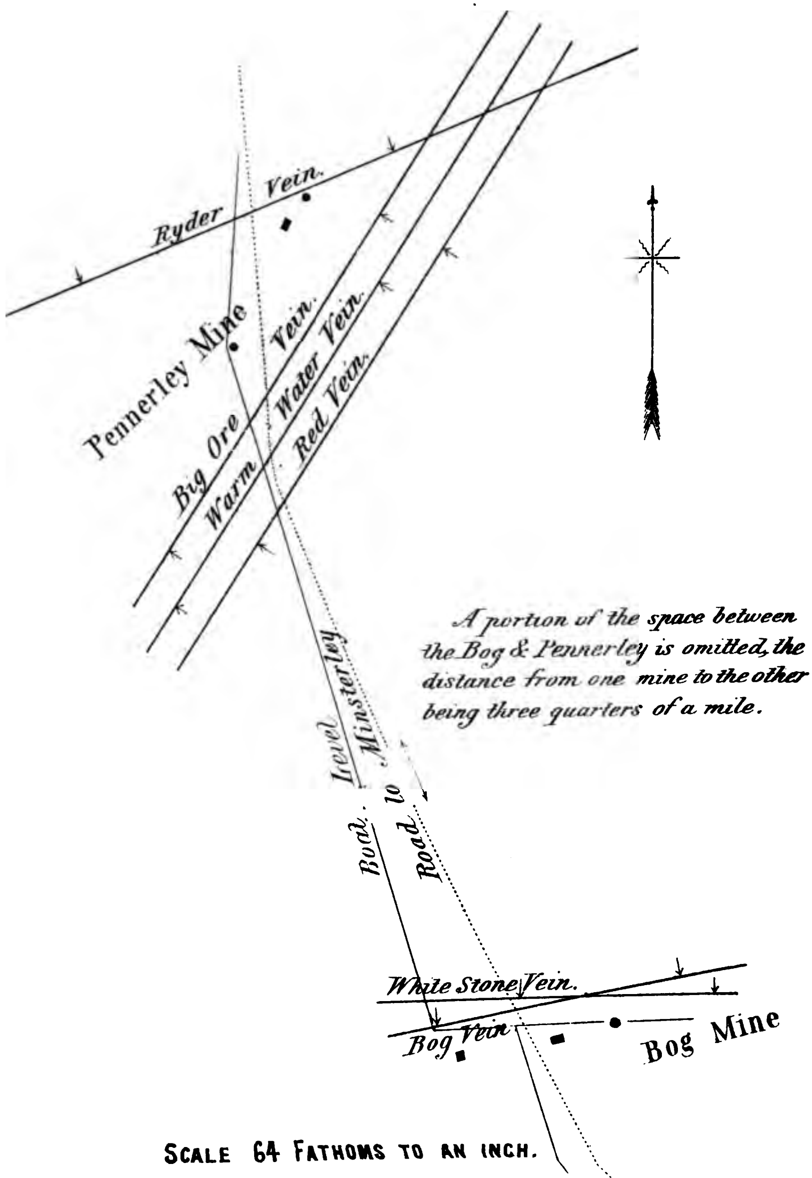
A reference to the map of the Geological Survey (No. 60, S.E) indicates the Ryder between the Grit Mines to be a greenstone dyke, and reference has already been made to a siliceous comb projecting above the surface. It extends along the north or underlying side of the vein, and is said by the miners to continue below the surface, wherever the lode has been worked. Though it is not a greenstone it is very probable that, if it could be examined for some distance underground, it would be found to be a felspathic rock, similar to that which crosses the Roman Vein at the Gravels, and the comb of the White Stone Vein at the Bog Mine. On the Survey Map the Weston Vein, the Ryder at Pennerley, and the White Stone Vein, are also indicated by a contiguous line of greenstone. Supposing these particular veins to have been originally dykes, it is evident that their sides must have become fissured, and that they were afterwards converted into lodes. If this was the order of their formation it confirms the conclusion, that the dykes and great protrusions of greenstone are older than the mineral veins, though there can be little doubt of it.

Pennerley and Bog Veins.

At the Pennerley Mine there are four important veins, viz., the Ryder, the Big Ore, the Warm Water, and the

PLATE 4.

Pennerley and Bog Veins.



Scale 64 Fathoms to an inch.

Red Vein. The Ryder crosses the other three veins at an angle of 35°, but does not appear to throw them off their course; neither are they considered to influence it. These veins hade to the N.W., with the exception of the Ryder, which inclines to the S.E. No greenstone or felspathic band has been noticed along the under side of the latter as shown on the Survey Maps. However, many years ago a deal of lead was obtained from it, so that its condition was then better known. At the present time it is the Big Ore Vein that is principally worked.

About three quarters of a mile to the south there is the Bog Mine, where two veins intersect each other at a small angle, and both hade to the south. The Bog Vein has been worked up to the Stiperstones; and it is said to have been turned and then lost on reaching those hard siliceous rocks. The White Stone Vein possesses a felspathic comb, usually on the north or under side, but sometimes on the other side.

The Bog Mine was discontinued working many years ago; but it is now connected with the Pennerley Mine, which is in active operation. James Nancarrow, Esq., and Captain R. Waters, have interested themselves in the geology of the district, and the latter has prepared a ground-plan (Pl. 4) of the outcrop of the veins, of which the following is a reduced representation. These mines have been worked to a considerable depth; Pennerley to 1,080 feet, and the Bog to 1,200 feet. The veins traverse slaty rock which crops out to the east, from beneath shale, under similar conditions to those of the mines already described, and a little to the north and west of Pennerley there are several masses of greenstone visible on the surface.

The following is a list of the mines in the country around Shelve:—

*1 SNAILBEACH.	15 EAST GRIT.
2 CENTRAL SNAILBEACH.	16 DINGLE.
*3 STIPERSTONES.	17 BENRE.
*4 OVEN PIPE.	18 SHELVE.
5 ROUND HILL.	*19 LADYWELL.
*6 PENNERLEY.	*20 ROMAN GRAVELS.
*7 BOG.	21 BATHOLES.
8 RITTON CASTLE.	22 HOPE VALLEY.
*9 SOUTH BOG OR ROCK HOUSE.	†23 MEADOW TOWN.
10 RHADLEY HILL.	†24 RORRINGTON, or WEST SNAILBEACH.
11 CEFN GWYNLLE.	††25 WESTON.
12 PULTHOLEY.	†26 OLD CHURCH, STOKE.
‡13 HEATHMYND.	††27 WHOTHERTON.
14 WHITE GRIT.	

It is a well-known fact in many mining districts that metalliferous veins are often productive of ore in particular beds only, and that when they run into different ground they change their mineral character. This is the case in the country around Shelve, where the lead ore has already been shown to occur only in strata that have a hard slaty character. In close proximity to the Gravels, strata of slaty rock can be seen dipping into the valley, in which the same beds are represented by a soft splintery shale. The slaty rock, when close to a greenstone dyke, is usually very hard, and often forms slates, presenting a flinty fracture when broken across the line of bedding, as on the highest part of Shelve Hill, where the dip is 30° E.S.E. There are, however, instances where the greenstone does not seem to have hardened the beds with which it came in contact; but these exceptions do not affect the fact that the veins occur in rock that is in proximity to greenstone, or at least where it probably

* These are Lead Mines, and are worked at the present time. Those without one are not worked.

†† Barytes Mines that are now worked. † Those that are not worked.

‡ Once worked for ochre.

exists beneath the surface. The valuable lead lodes are peculiar to the strata of the Lower Llandeilo (or Arenig) series. The overlying grits of the Upper Llandeilo and the succeeding strata contain veins which have occasionally yielded some lead ore, but are now worked for barytes, which is obtained in large quantities. That the lead ore occurs only in the slaty rock, and not in the shale, is a fact that has been long known to the miners of the district, and has been illustrated by the operations at the Whit Grit Mine. It is for this reason that the mineral veins of Shelve are not worked continuously for any great distance, for no lode has been proved in a continuous line for a mile in length, while the average workable length is very considerably less.

Some of the local miners entertain the opinion that many of the veins extend in an unbroken line across the country for a considerable distance. The Pennerley, Grit Ryder, and the Barytes Vein at Priest Weston, all of which appear to be on the same line, are considered to form an example. It is certainly probable that these particular veins may have a connection, and the geological surveyors perhaps considered so, when they found data for assuming them to have been similar greenstone dykes. But in this and other instances the theory chiefly rests, if not entirely, on the coincidence of position, though that described seems the only one that is remarkable. The study of the ground-plans that have been described does not favour the theory of veins extending for any considerable distance, but to rather an opposite conclusion. The ground-plans represent three areas, in which the direction and length of each vein is well known, and either has been, or is now worked, and the principal veins have been found invariably to end in the shale, which always comes in at no great distance, while the others are of limited extent, and are usually branches from the more important lodes.

The mineral veins around Shelve do not present much uniformity in relative position. It was expected that an examination of them would have resulted in some order being discovered by means of which they could be classified into distinct sets, according to the direction of the single veins, and that the conclusions deduced would have been of some practical value; but this has not been the result so far as the observations have been made. It was also contemplated to publish a map indicating the principal veins, where worked, and their probable line of bearing across the country, but the idea was abandoned, as it became evident that the veins seldom continue far, and it was unadvisable to indorse opinions regarding the prolongation of lodes through ground in which they are ***not likely to be found.*** That veins occur in the direction of all the points of the compass, is partly evident from the following diagram, which contains only the lodes shown on the three ground-plans, and the star-form would be more complete, and crowded with lines, if all the workable veins in the district could have been introduced. The average direction of the greatest number of the Shelve Veins is, however, W.N.W. by E.S.E., and there are few veins at a right angle to those points.

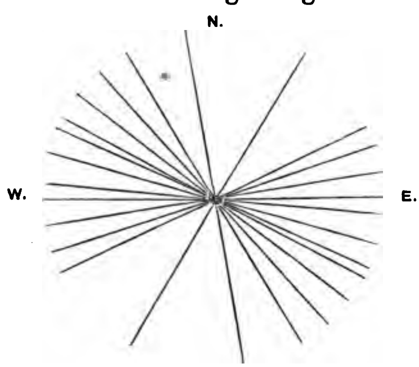


Diagram showing the direction of Veins at the Gravels, White and East Grit, and Pennerley and Bog Mines.

The principal veins, such as the Ryders, at Pennerley, and the Grit Mines, and the Cross Course at the White Grit, are probably lines of dislocation; but it is impossible to ascertain the extent of the throw in any of them, though on the whole it appears to be insignificant. Most of the veins are simply fissures containing fragments of the same slaty rock as their walls, with the interstices filled with Calcite and irregular strings and nests of Galena and Blende, or almost entirely filled with Baryte. The veins that have originated as fissures probably graduate into faults, for the opposite sides must have been very liable to displacement.

Although the mineral veins of Shelve contain so much lead, with a mere trace of copper, it is remarkable that between the hilly ridge of the Stiperstones and the Longmynds copper is said to be abundant, and a mine has been opened at Westcott where the ore (Redruthite) is unusually rich. The direction and value of the veins in that district are unknown, and as they have not hitherto been worked, the success of the undertaking seems to be very doubtful. The veins on the east of the Stiperstones have no connection with those immediately around Shelve, though it is possible that the latter may contain copper, at a considerable depth, if they penetrate to the Cambrian strata. It is remarkable that in the Upper Llandeilo rocks the veins principally contain barytes, the Lower Llandeilo rocks lead, and the Cambrian rocks copper.

In this communication an endeavour has been made, by personal observation, and from much valuable information obtained from the managers of the mines in the district, to describe the mineral veins of Shelve. The descriptions that have been given, and the conclusions that have been stated, are as clear as the materials at command will allow. With regard to the value of the mineral ground,

and the future prospects of successful mining in the district, it can only be said that it resembles many other localities in uncertainty, for no laws have been discovered by means of which the working of veins can be carried on with any certainty of success.

The Shelve Veins afford few attractions to the mineralogist. Those of Snailbeach and Oven Pipe are the only lodes where those cavities occur in which the minerals had free space to assume a definite crystalline form, and the former mine is remarkable for its fine crystals of Calcite, covered with smaller ones of Quartz. At the Oven Pipe Mine some very beautiful acicular crystals of Calcite have been collected by Captain Waters, and very large cubical crystals of Galena also occur at the same place. Small crystals of Quartz and Blende are common, but it is very rare to see specimens, either of these or any other minerals, worth preserving. The following list contains all the species that are known to occur in the district; but though particular localities are appended to each, it is very likely that most of them might be found at any mine that is extensively worked.

List of Minerals found in the Veins around Shelve.

Quartz,	Gravels and other Mines.
Calcedony,	White Grit Mine.
Calcite, Carb. of Lime.	All the Mines.
Pseudomorphs of Fluor Spar, Flurate of Lime.	Gravels Mine.
Baryte, Sulphate of Barytes.	Cefn Gwynlle.
Witherite, Carb. of Barytes.	White Grit Mine.
Petroleum, Bitumen.	Oven Pipe ,,

Pyrite, Sulphuret of Iron.	White Grit Mine.
Malachite, Green Carb. of Copper.	Gravels ,,
Redruthite, Sulphuret of Copper.	Westcott ,,
Wad, Earthy Manganese.	White Grit ,,
Galena, Sulphuret of Lead.	All the Mines.
Minium, Oxide of Lead.	Snailbeach & White Grit Mines.
Cerussite, Carb. of Lead.	Snailbeach & White Grit Mines.
Blende, Sulphuret of Zinc.	All the Mines.

THE BREIDDEN HILLS.

"THE Geology of the Country around Shelve" would be incomplete without a description of those lofty and conspicuous hills, occurring in a group, about ten miles to the N.W. of that district. The Breidden Hills are close to the railway between Oswestry and Welshpool. The principal elevations are Breidden Hill (proper), composed of a dark-coloured greenstone, and Moel-y-golfa and Middletown Hill, both of which are made up of trap-breccia and ash-beds. Middletown Hill is the highest, being 450 feet above Bellisle, and about 1,200 feet above the sea. This group of hills is surrounded by Llandeilo strata, which with the associated ash-beds of igneous origin dip to the S.E. at a considerable angle, being in some places nearly vertical. The locality is a remarkable one, for many interesting phenomena can be seen within five or six square miles, as the greatest length of the district is only four miles, and the breadth one and a-half miles.

The rocks composing the hills are all well exposed, and there are several varieties of porphyritic and amygdaloidal greenstone, trap-breccia, and ash; some of the latter are quarried for a felstone, which is of a light grey colour, and obtained in considerable quantities. The slaty rocks and shales of Llandeilo age occur both under and over the beds of breccia and ash, which form a central stratified band.

No fossils have been found; but the lithological characters enabled the Government Geological Surveyors to correlate them with similar strata around Shelve, and the result will be found on reference to the Survey Map No. 60, N.E., and Section 36.*

The stratified series of the Breidden Hills seem to represent the lower ash-beds of Shelve with a few hundred feet of both the underlying and overlying slaty beds and shales. The greenstone of Breidden Hill is probably of the same age as that of the Corndon, and is also a great mass of eruptive rock, that has burst upwards through the strata, after they had accumulated at the bottom of the sea.

The igneous rocks present the chief point of interest in the geology of the district, and especially the greenstone breccia of Moel-y-golfa and Middletown Hill. It seems to be a regularly bedded breccia, and not a broken up eruptive rock, and has probably been derived, along with the ash, from a source long antecedent to that of the greenstone of Breidden Hill.

In this small area the geologist will find a picturesque spot, possessing the highest geological interest.

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* In *Siluria*, 3 ed., p. 89, there is a woodcut showing this section.